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NBS BUILDING SCIENCE SERIES 130

User Acceptance of an Energy Efficient Office Building-- A Study of the Norris Cotton Federal Office Building

ENERGY EFFICIENCY
PRESIDENT'S PROGRAM FOR ENERGY EFFICIENCY

U.S. DEPARTMENT OF COMMERCE • NATIONAL BUREAU OF STANDARDS

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User Acceptance of an Energy Efficient Office Building-- A Study of the Norris Cotton Federal Office Building

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ABSTRACT

The General Services Administration built the Norris Cotton Federal Office Building in Manchester, New Hampshire, and chose it as a "demonstration project for studying the effectiveness of energy conservation techniques in the design and operation of a contemporary office building." User acceptance of both the innovative and conventional design features in the building was measured by administering a questionnaire to employees shortly after occupancy of the building and again eight months later. The most positively rated feature overall was the lighting, but reaction to the high pressure sodium lighting system as installed in the Norris Cotton Building was strongly negative. Response to noise levels and disturbances was about evenly divided, but workers in open-plan offices were less satisfied with the noise climate than workers in partitioned offices. Most respondents were dissatisfied with the temperature and ventilation conditions and the small windows in the building. In general, the occupants rated the building much higher in appearance than their previous offices, slightly higher in terms of suitability for performance of their jobs, and slightly lower with respect to comfort. A literature review of recent survey studies of the office environment is included.

Key Words: Energy conservation; lighting; man/environment research; noise; office building; post-occupancy evaluation; questionnaire; temperature; user needs; ventilation; windows.

PREFACE

This report is one of a group documenting NBS research and analysis efforts in developing energy and cost data in support of the Department of Energy (DoE)/National Bureau of Standards (NBS) Building Energy Conservation Criteria Program. This work was supported by DoE/NBS Task Order A008-BCS under Interagency Agreement No. EA 77 A 01 6010.

Cover photo:

The Norris Cotton Federal Office Building.

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Facing page:

Interior of an open-plan office in the Norris Cotton Building.

1. INTRODUCTION

The General Services Administration (GSA) built the Norris Cotton Federal Office Building in Manchester, New Hampshire, and chose it as a "demonstration project for studying the effectiveness of energy conservation techniques in the design and operation of a contemporary office building" (Rensberger, 1978). The building was dedicated on October 8, 1976, and was designed from the beginning with high priority given to energy conservation. Both conventional and innovative energy conserving technologies are incorporated in the Norris Cotton Building.

The National Bureau of Standards (NBS) evaluated and monitored the building for the Department of Energy (DoE). The evaluation was carried out by a multidisciplinary team of NBS researchers with the assistance of consultants and other experts. Five areas were evaluated:

- Energy -- heating and cooling
- Solar system
- Interior lighting
- User acceptance
- Economic analysis

1.1 SCOPE OF THE REPORT

This document reports user* acceptance. In determining how the innovative design features of the Norris Cotton Building compare with more conventional design features, it is important to determine not only the engineering and economic performance of these features but also user reaction to them. A questionnaire was developed to assess occupant response. The questionnaire explored occupant reaction to the building in general and more specifically to the energy conserving design features as they affected the sensory environment experienced by the occupants.

1.2 ORGANIZATION OF THE REPORT

Section 2 summarizes the recent survey research literature on the office environment. These studies provide a background for the evaluation of the Norris Cotton Building and a context within which the results of the evaluation may be assessed.

Sections 3, 4, and 5 are related to the study of the Norris Cotton Building. The energy conserving design features and physical layout of the building are described in section 3. Section 4 presents the research approach and section 5 gives the results of the Norris Cotton Building study.

In section 6, the results of the Norris Cotton Building study are explored with reference to the other evaluation studies presented in section 2.

Section 7 provides a summary and presents the research conclusions.

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* In its broadest sense, "user" includes both employees working in the building and visitors to the building. An assessment of visitor response was beyond the scope of this study and unless otherwise noted "user" is synonymous with "occupant" or "employee."

Facing page:

Interior of a private office in the Norris Cotton Building.

2. BACKGROUND

This section reports a literature review that concentrates on recent survey studies of the office environment. These studies have tended to focus on the "open-plan" office -- the predominant type in the Norris Cotton Building. The review does not cover many studies prior to 1965 which dealt exclusively with conventional, partitioned offices.

Figure 1. A typical open-plan office

In contrast with the conventional, partitioned office, the open-plan office has no ceiling-high walls between individual work areas; instead, screens or movable acoustical barriers, plants, cabinets, and bookcases are used to define work stations and provide visual and acoustical privacy (figure 1). Advocates of the open-plan office claim it greatly reduces initial costs of installation, requires less energy for operation, makes more efficient use of space, enables regrouping of work stations in response to changing work demands, and improves communication among workers. Perhaps because these assertions have not been adequately proven to the satisfaction of all designers, many "traditional" offices are still being built.

2.1 NATURE OF PREVIOUS EVALUATION STUDIES

Although recent survey studies, conducted primarily in Europe and the United States, have sought to determine how well open-plan offices meet the visual, acoustical, and thermal comfort needs of those who work in them, the existing building evaluation literature does not yet provide an adequate basis for making design decisions. As Lozar (1978) observes, "The environmental psychology research literature presently in existence appears fragmented, has many different factors involved, and does not provide a consistent basis for overall generalizability to habitability factors."

One reason why generalization is difficult is that many studies have been concerned only with the evaluation of a particular building. As Elder, Turner, and Rubin (1979) point out, "informational needs in such cases are highly specific, as are the research methods employed."

Another problem is that reported studies, by and large, do not establish correlations between subjective responses, such as attitudes or preferences, and physical design parameters. The physical environment has not always been carefully described or measured, and even when precise physical data are available, they cannot always account for the observed user response. Studies have often shown that simple relationships between the intensity of physical stimuli and the responses of office occupants cannot be assumed and that qualitative considerations are also important. Nemecek and Grandjean (1973), for instance, found that informational content of conversational noise rather than loudness was a better predictor of the amount of disturbance experienced by office occupants.

2.2 GENERAL RESPONSE TO OPEN-PLAN OFFICES

How do user attitudes towards the open-plan office compare with those towards the conventional, partitioned office? In general, the data regarding user satisfaction with the two types of offices are inconclusive, reflecting the variety of contexts and methods under which such studies have been carried out. Nemecek and Grandjean (1973), for example, studied user response in six different open-plan office buildings in Europe and reported that 59 percent of those surveyed would accept another job in a large-scale office, while 37 percent preferred a

conventional one. They concluded that "the advantages of the large-space office outweigh the disadvantages for the majority of those concerned." Harris (1978), on the other hand, found that a sample of employees drawn from a number of conventional offices in the United States were more positive about their workplaces than were those working in open-plan offices.

Some studies have appeared to indicate that the open-plan office is superior to the conventional office in appearance but not in function. As Brookes (1972) notes, "it looks better but it works worse." Elder et al. (1979) similarly found that occupants of the offices in the building they studied (over 80 percent of which was open-plan) judged their offices to be much better in appearance than the previous offices occupied, but slightly worse in suitability for performance of their jobs. Many open-plan offices that are studied have new finishes and furnishings and this fact presents a methodological challenge to attempts to compare their appearance with that of conventional offices that may not have been as nicely furnished.

2.3 RESPONSE TO SPECIFIC DESIGN FEATURES

2.3.1 Lighting

Survey studies have often shown that occupants consider lighting as one of the most satisfactory aspects of the office environment. Wolgers (1973), Boyce (1974), and Elder et al. (1979) all found overwhelmingly positive response to the lighting in the open-plan offices they studied; in the latter instance, only four percent expressed dissatisfaction with it.

Some studies have examined the relationship between illumination levels and occupant satisfaction. Nemecek and Grandjean (1973) found that lighting levels between 400 lux (37 footcandles) and 850 lux (75 fc) were judged best and were associated with fewer visual problems than were levels beyond 1000 lux (93 fc). Boyce (1974) found that levels of 400 lux (37 fc) were judged satisfactory, and 800 lux (74 fc) more satisfactory. Kraemer et al. (1977) measured light levels of generally between 600 lux (56 fc) and 900 lux (84 fc) and reported that most people felt the lighting was satisfactory. These studies were all conducted in Europe and the ranges of satisfactory light levels reported might not be generalizable to other cultures.

There is some evidence, however, that factors such as brightness contrast and direct glare from lamps are also important predictors of satisfaction with lighting. Kraemer et al. (1977), for example, found that the level of illumination at work stations "influenced people's opinions either for or against lighting and office conditions" in 65 percent of all cases; lighting contrasts on the ceiling and in adjacent areas influenced opinions 75 percent of the time; and shading of lamps did so in 80 percent of all cases. The authors conclude that these

results show the importance of properly shading lamps to avoid direct glare and adhering to standards for the contrast range of colors and materials when designing rooms.

Another qualitative factor affecting opinion is color rendition. Laboratory research (Aston and Bellchambers, 1969) has shown that if people feel a light source provides good color rendition, they are satisfied with less light than if the source gives poorer color rendition. A survey study by Williams (1975) showed that high pressure sodium lighting, which is efficient but gives certain colors an unusual appearance, was generally acceptable to users, but Flynn (1977) concluded that high pressure sodium lighting "should probably not be simply substituted for the more conventional spectra developed by the common fluorescent sources" when subjective acceptability is an important consideration. Williams lists the following conditions as "usually necessary for high pressure sodium lighting to be fully acceptable:"

(1) The space should be lighted only with HPS sources.

(2) The colors of room surfaces and furniture should be selected under HPS lighting.

(3) HPS lighting looks better the further the illumination level is increased above 50 footcandles.

Several studies have appeared to show a strong preference for daylight over artificial light (Manning, 1965; Wells, 1965; Markus, 1967). Elder et al. (1979) found that over 70 percent preferred a combination of natural and artificial light, but that those who favored only natural light outnumbered those who favored only artificial light by almost a 2:1 margin. There appears to have been little research done on the relationship between satisfaction with lighting and the ratio of daylight to artificial light. Elder et al. (1979) found extremely high satisfaction (93 percent) in a building with 100 percent glazing on two facades, but Ruys (1970) found that response was also positive in the absence of any daylight.

One methodological problem associated with survey studies of daylighting preference is the difficulty of controlling for potentially confounding variables such as view and illumination level. For instance, to what extent is the preference for daylighting really masking a preference for view or higher light levels? A clearer understanding of the relative importance of daylight, view, and illumination levels to building occupants would provide useful information to building designers, but determining these relationships requires a high degree of control over experimental conditions that is usually possible only in laboratory studies.

The task/ambient concept of lighting, emphasizing the concentration of light in areas where it is needed, has been incorporated into many open-plan offices in the form of "systems furniture" lighting, in which

the main light source is built into the work station itself. The advantage of lighting at the work station is that desks can be moved without seriously affecting the lighting, and energy may be saved by eliminating overillumination of nonwork areas. Goodrich (1978) reported very high acceptance of task lighting in the building he studied. However, research on the user response to task lighting has been limited, and has been hampered by the fact that the superior furniture and decor generally associated with the use of task lighting may influence opinions of it. Thus, any conclusion about the general acceptability of task lighting would be premature without further research.

2.3.2 Noise

Although acoustical comfort appears to be fairly important to office occupants (Harris, 1978; Elder et al., 1979), noise is a common source of dissatisfaction in open-plan offices. Nemecek and Grandjean (1973), for instance, found that 35 percent of the people in their study of open-plan offices were severely disturbed by noise and that only 20 percent were not bothered at all. They also found that "acoustic disturbances" were more than twice as numerous as "visual disturbances." Kraemer et al. (1977) reported that 58 percent of those surveyed said there were certain noises which they found particularly disturbing in their offices, and Elder et al. (1979) found that 54 percent felt their offices were sometimes so noisy that it was difficult to work.

The response of office occupants to the acoustical climate does not appear to be simply a function of noise level. Rather, the relationship between potentially disturbing noises and the background noise level appears to be of primary importance in determining the level of occupant satisfaction. As Lloyd (1974) notes, unsatisfactory conditions can result from too little noise in the office as well as too much, because a certain amount of background noise is necessary to mask impact sounds and voices. In recognition of this fact, designers will often introduce background noise, such as music or "white" noise, into open-plan offices to lessen distractions from peak noises and to improve speech privacy. Such noise often has a spectral shape that allows it to blend in with other background noises, such as ventilation system noise.

Noise from conversations has frequently been identified as the most disturbing type of noise in open-plan offices (Brookes, 1972; Nemecek and Grandjean, 1973; Elder et al., 1979). Nemecek and Grandjean (1973) found that conversations were the most disturbing office noise not because they were particularly loud, but because of their information content. Boyce (1974) concluded that information content and unpredictability were largely responsible for noise disturbances. Office machines and telephones are usually mentioned as other major sources of noise, but the distribution of office machines can have a significant effect on how annoying they are. Kraemer et al. (1977) noted that where

typewriters were scattered throughout the office, 43 percent of the people surveyed considered them very disturbing, but where they were grouped together, only seven percent did.

A problem frequently associated with open-plan offices is the absence of auditory privacy. Designers have used several techniques to try to ensure auditory privacy, including masking noises, lightweight partitions, and increased distances between occupants. These techniques do not appear to have achieved a high degree of success, however. Harris (1978), for example, reported that open-plan office workers generally felt they had less conversational privacy than did workers in conventional offices and Elder et al. (1979) found that occupants of open-plan offices frequently complained of the lack of privacy.

Some studies of open-plan offices have indicated that internally generated noise is much more of a problem than outside street noise. Nemecek and Grandjean (1973), for example, reported only a single mention of external noise, and Elder et al. (1979) found that only three percent were bothered by it in a "sealed" building whose windows could not be opened. By contrast, studies of conventional offices have often shown that street noise is more disturbing to occupants than internal noise (Manning, 1965). However, factors other than differences in interior space design make it difficult to compare the relative contributions of internal and external noise to acoustic conditions in open-plan and conventional offices. For instance, since conventional offices are, as a group, older than open-plan offices, they are more likely to use natural ventilation. The location of an office with respect to street traffic is another important factor.

The response to office noise has been found to vary with the type of occupation. Nemecek and Grandjean (1973) found that only about 10 percent of managers were not bothered by noise, compared to 30 percent of the clerical workers. Boyce (1974) similarly noted that about 70 percent of the managers and professionals were often disturbed by noise, whereas only about 45 percent of clerical and secretarial workers were.

2.3.3 Temperature and Ventilation

Cooper, Hardy, and Wiltshire (1974) and Elder et al. (1979) identified thermal comfort as a very important quality of satisfactory office environments. Nemecek and Grandjean (1973) and Kraemer et al. (1977) reported positive responses to temperatures during both summer and winter. Most of the offices in these studies had room temperatures of 70°-75°F (21°-24°C). On the other hand, Boyce (1974) noted problems, especially during the heating season; room temperatures in his study averaged about 70°F (21°C). Wolgers (1973) also found a somewhat negative response, and Elder et al. (1979) found extreme dissatisfaction, although actual temperature levels were not reported in either study.

A common technique used in studying the thermal comfort of office workers has been to ask them to vote at regular intervals on the quality of the thermal environment. Humphreys and Nicol (1970) used this approach in a study of British office workers. Each desk was provided with a monitor on which a vote was cast every hour. A seven-point continuum scale was used, with "much too warm" and "much too cold" as the endpoints. Humphreys and Nicol found that if people were properly clothed, they could be comfortable over a rather wide range of temperatures. They also noted that simple globe temperature measures predicted thermal comfort as well as did more complex measurements.

The question of how to extend the range of temperatures in offices without causing worker discomfort has received attention recently. Gagge and Nevins (1976) conducted a questionnaire survey of thermal preferences in a Federal office building to determine reaction to temperatures of 68°-70°F (20°-21°C) in winter and 78°-80°F (26°-27°C) in summer. They found that the lower temperatures could be made acceptable to 80 percent of suitably dressed persons if their legs and feet were covered, while the higher temperatures could be made acceptable by wearing lighter clothing, increasing air movement, or reducing humidity.

Some survey studies have shown statistically significant sex differences in the response to temperature, with women reporting that they feel too cold much more often than men. This may be due to the fact that women dress more lightly than men rather than to any biological difference, since laboratory studies in which both groups were equally clothed have not shown any such differential sensitivity to temperature (Fanger, 1977).

Ventilation is often studied in conjunction with temperature, perhaps because of the way in which these two features closely interact to determine satisfaction. Proper ventilation, for instance, requires an optimum rate of air movement that varies with temperature. Cold temperatures in combination with excessive air movement produce complaints of draftiness, while increased air movement is desirable when temperatures are warm to avoid feelings of stuffiness.

Studies of the response to ventilation in offices have dealt mainly with the problem of drafts. Nemecek and Grandjean (1973) noted that 30 percent of those surveyed reported being disturbed by drafts, but the researchers were unable to account for this finding in terms of the existing physical conditions (rates of air movement). Kraemer et al. (1977) found that 60 percent of the office occupants they questioned never noticed drafts. Elder et al. (1979), however, found widespread dissatisfaction with the ventilation, although the physical basis of this negative response was not clear.

Ventilation problems typically occur more often for women than for men (Nemecek and Grandjean, 1973; Boyce, 1974; Kraemer et al., 1977). The reason for this appears to be that women tend to wear lighter clothing than men and are thus more affected by cold drafts.

2.3.4 Windows

In addition to increasing the amount of light in offices, windows serve as an important component of the visual environment by providing occupants with sunshine and a view, or visual contact with the outside world. Elder et al. (1979) found that the most often mentioned advantages of windows were providing a change of view to break monotony, allowing the occupant to see what the weather was like, and providing sunshine. Collins (1975) has summarized the literature on psychological reactions to windows.

Research on user response to windows has concentrated on such topics as the general importance of windows to building occupants, identification of window benefits, and preferred window size and shape. Survey methods have been used extensively in the first two areas, while experimental techniques are common in studying size and shape preferences.

Although windows may not be as important to building occupants as other environmental features, such as noise, temperature, and lighting (Elder et al., 1979), their absence from a building can cause considerable dissatisfaction. Ruys (1970), for example, surveyed workers in five windowless office buildings and found that 90 percent expressed dissatisfaction with the lack of windows and nearly 50 percent thought this had an adverse effect on them or their work. Similarly, Elder et al. (1979) found that almost half of those surveyed said it was "very important" to have a window in their office, while only 13 percent said it was "not important."

View appears to be the most important window benefit for office workers (Collins, 1975, pp. 53, 76). Wells (1965) reported that 90 percent thought it was important to have a view of the outside world, while only one percent thought a good view was not important. Cooper et al. (1974) found that only 13 percent felt a good view was not important. Keighley (1973a), using a scale model approach, determined that window satisfaction was strongly influenced by the quality of the view.

Another important benefit provided by windows is sunshine (direct sunlight). In a survey by Ne'eman and Longmore (1973), 73 percent of office workers wanted some sunshine in their offices, while only 24 percent thought sunshine was a nuisance. Ne'eman and Longmore found that the desire for sunshine depended on the type of building, the kind of activities performed, and the amount of occupant control over sunshine. In homes, for instance, where occupants can regulate their exposure to direct sunlight by using shading devices or by simply moving out of the sun, 90 percent or more of those surveyed wanted sunshine, while in schools, where occupants generally do not have access to shading devices and spend most of their time in fixed sitting positions, only 42 percent wanted sunshine. There was also a dramatic difference in the desire for sunshine between hospital patients, on the one hand, and the hospital staff, on the other. Only two percent of the patients

thought sunshine was a "nuisance," while 62 percent of the hospital staff did. Ne'eman (1974) suggests that "the difference in the response to the Sun by people performing different activities within the same interior is an important criterion for proper environmental design."

Boyce (1974) and Elder et al. (1979) studied satisfaction with window size using survey methods. In the study by Boyce, windows covered only 13 percent of the exterior walls, while in the study by Elder et al., the entire north and south facades were glazed. Boyce found that although occupant opinion of the window size was slightly more positive than negative, there was much variability of response and a substantial minority was dissatisfied. Elder et al. found that 65 percent were satisfied with the window size, while only 16 percent were dissatisfied.

Some researchers have tried to determine acceptable window sizes and shapes by using scale model techniques in which an office environment of reduced size is presented to the subject. Window size and shape are either adjusted by the subject or systematically varied by the researcher. Using this approach, Ne'eman and Hopkinson (1970) found that in order to satisfy 50 percent of the people, a window had to cover at least 25 percent of the wall; to satisfy 85 percent, it needed to cover at least 35 percent of the wall. Ne'eman and Hopkinson also found that window width was more important than height in determining preferred size, and that preferred shape depended on the distance from the window and on the type of view (near or far). Keighley (1973b) also used a scale model approach and concluded that for optimum user satisfaction, a window must occupy at least 20 percent of the wall. In a related study, Keighley (1973a) determined that a wide window was preferable to a narrow one. Ludlow (1976) studied preferred size and shape as a function of view for a scale model of an open-plan office. View content and distance from the window were found to have significant effects on size and shape preferences. Ludlow agreed with Ne'eman and Hopkinson (1970) and Keighley (1973a) in finding that horizontal views were preferred to vertical ones, but disagreed with them in that he found much larger preferred window sizes (50-80 percent of the exterior wall).

For most people, the benefits provided by windows appear to be more important than any drawbacks, such as letting in hot air in summer and cold air in winter, glare, and outside noise. Although some sunlight is often preferred by building occupants, an excess of it can produce both visual and thermal discomfort. Elder et al. (1979) found that overheating due to windows was often a problem according to 27 percent of those surveyed, and that 29 percent often noticed cold drafts near windows. Since the windows in that study covered 100 percent of two of the exterior walls, however, these results may not be typical of office buildings with less window area. Also, some people may have responded to the HVAC system instead of to the windows. Despite the large windows, only three percent were often bothered by

glare, and no one was especially bothered by noise near the windows. Nemecek and Grandjean (1973) also reported that window glare was not a serious problem in "strongly lit" offices.

2.4 CONCLUSIONS

The research studies which have been reviewed in this section provide a context for the evaluation of the Norris Cotton Building. As evidenced by the studies examined here, the field of building evaluation lacks the standardized methods of investigation and the information base that would allow precise comparisons with other buildings. Nevertheless, the patterns of responses obtained in these studies can serve as a general basis for comparison with the responses obtained in the Norris Cotton Building surveys.

Facing page:

Solar overhangs and vertical fins on the exterior facades of the Norris Cotton Building reduce glare and overheating.

3. DESCRIPTION OF THE NORRIS COTTON BUILDING

The Norris Cotton Building is considered a "living laboratory" for testing and evaluating methods to conserve energy in office buildings. It is among the first Federal buildings to be designed with energy efficiency in mind throughout the design process and is one of the few buildings in which energy consumption has been thoroughly monitored.

The Norris Cotton Building is located in downtown Manchester, New Hampshire (figure 2). The building is nearly cubical in shape, has two underground levels of parking garage, seven office floors, and a mechanical penthouse. The building contains approximately 97,600 square feet (9,070 square meters) of office space and 78,740 square feet (7,320 square meters) of garage and mechanical space. Among the significant unique features incorporated in the building are:

- a variety of interior illumination systems;
- innovative energy conserving heating, air conditioning, and ventilating systems and in conjunction with these massive exterior walls with the insulation on the exterior side of the masonry, between the masonry and facing panels to minimize the effects from outdoor temperature;
- no windows on the north wall and small window areas on the south, east, and west walls to reduce heat loss.

The energy consumption of the building is monitored by means of sensors and meters throughout the building. An extensive instrumentation system was specified for the building using a commercially available minicomputer-based building monitoring and control system. The system is used to calculate hourly average values in engineering units from approximately 700 temperature, humidity, flow, radiation, electric energy, and illumination sensors.

Due to unforeseen delays, the instrumentation system did not become operational until after both questionnaires had been administered. Therefore, only sketchy physical measurements were available during the time occupant response data were being collected.

3.1 ENERGY CONSERVING DESIGN FEATURES

3.1.1 Lighting

Six different illumination systems, all drawing approximately the same power per unit floor area, are used in the building. Table 1 lists the luminaire types installed on the various floors. The first and third floors have identical luminaires, but differ in the type of lenses installed (i.e., the extent of polarization of the light). The second and sixth floors have identical lighting systems, but differ in the amount of fenestration, and therefore, the amount of daylighting. On the second floor, photoelectric cells automatically turn off the artificial lights when natural light levels are sufficient. The three perimeter rows of lighting along the south, east, and west sides of the building are connected to three independent photoelectric switches which switch the lights off one row at a time from the extreme outer row to the inner rows when sufficient daylight is available. These cells are equipped with a 30-second time delay device to prevent the

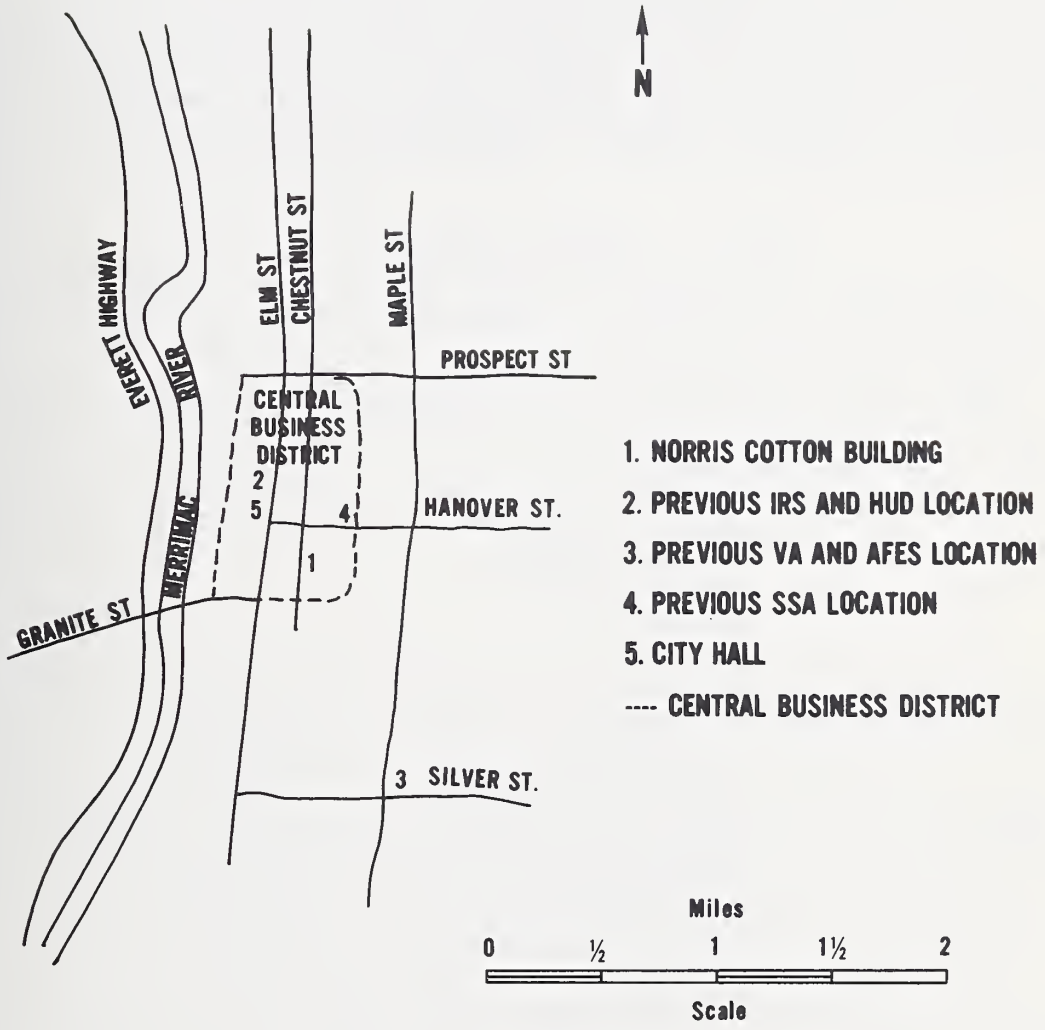

Figure 2. Map of Manchester, New Hampshire, showing the location of the Norris Cotton Building and the Federal agencies prior to their relocation to the Norris Cotton Building

lights from switching off and on when outside light levels change for brief periods. (In actual use, the photocells almost never received enough daylight to be triggered.) The fourth floor has high pressure sodium lamps. These lamps differ from the fluorescent in two ways: 1) a large percentage of the light emitted is in the yellow region of the visible spectrum, and 2) the high pressure sodium lamps have a longer warm-up time (it is several minutes from the time the switch is activated before the lamp reaches full light output). The fifth floor has "systems furniture" with built-in task lighting. Each desk is illuminated by metal halide lamps mounted in the top of an adjacent cabinet. These lamps provide indirect illumination by reflecting light off the ceiling onto the work surface. An additional work surface underneath the cabinet is directly illuminated by fluorescent lamps.

Table 1. Lighting Systems in the Norris Cotton Building

Floor	Lamp Type	Lens Type
1	Fluorescent	Prismatic
2	Fluorescent (plus natural lighting and photocell control on perimeter)	Twin beam
3	Fluorescent	Polarized
4	High Pressure Sodium	Prismatic
5	Metal Halide and Fluorescent	Task-lit systems furniture
6	Fluorescent	Twin beam
7	Fluorescent	Prismatic

NOTE: The lamps and lenses on floors one and three are interchangeable.

After the building had been occupied for eight months (May 1977), NBS made physical measurements of the various illumination systems. Tables 2 and 3 give illumination levels and contrast rendition factors* obtained for each system.

3.1.2 Heating, Ventilating, and Air Conditioning (HVAC) Systems

The HVAC systems at the Norris Cotton Building include heat pumps, fan coil units, heat storage and recovery devices, variable volume air distribution, and liquid-heating solar collectors. Each of the floors in the building utilizes a different type HVAC system. Table 4 lists the HVAC systems installed on the various floors. As table 4 shows, there are two main types of systems: heat pump systems, which are used on floors one through three; and central equipment systems, on floors four through seven.

In February 1977, measurements of the temperature and ventilation conditions in the building were made. A thermographic study (Richtmyer et al., 1979) showed that there were more cold surfaces on the first three floors of the building, especially on the east and west walls. Concurrent ventilation measurements using a tracer gas (Hunt, 1979) revealed that the air in the building as a whole was replaced by fresh air from the outside at the rate of about 0.75 changes per hour. The air change rate on the first three floors, however, was much higher than on the upper four floors (1.03 and 0.54 changes per hour, respectively).

3.1.3 Windows

There are no windows on the north facade (service functions have been placed against this wall). Windows on the east, west, and south facades allow about six percent fenestration, with a 1.2 ft x 5.3 ft (0.4 m x 1.6 m) window every 10 feet (3 meters). On the second floor the window area encompasses 12 percent of the exterior wall area on the east, west, and south facades in order to increase the amount of natural light. The additional windows are long, narrow, and placed horizontally near the ceiling between the vertical windows (figure 3). Also there is a six-foot overhang above the windows on the second floor. All of the windows are double-glazed (the interior glazing is clear and the exterior glazing has a bronze tint) with venetian blinds built into the space between the glass panes. The blinds are fixed in the down position with the slats at the horizontal angle (figure 4).

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* Contrast rendition factor is a qualitative measure of the lighting determined by dividing the contrast of the task under the lighting system by the contrast of the task under a reference lighting system in which the light flux on the task is equal from all directions. The higher the contrast rendition factor is, the better the lighting.

Table 2

Illuminance (dekalux) at Task Surface with Contrast Measuring Instruments in Place

Floor	Location[2]	North[1]			East			South			West		
		R	0	L	R	0	L	R	0	L	R	0	L
1	NC2	99.2	90.1	98.6	97.5	90.2	98.2	95.4	87.7	97.4	96.8	87.7	96.3
	NC1	88.2	95.2	88.8	102	115	102	87.2	112	102	87.2	93.6	86.6
	NC1	98.0	105	96.8	96.8	105	97.9	96.8	104	96.8	97.1	105	97.9
	NC2	93.5	85.0	94.5	94.8	86.2	93.8	94.8	86.9	94.3	94.8	86.1	93.6
2	DR1	66.3	68.9	67.8	60.6	64.8	69.7	66.0	60.5	65.1	72.6	66.6	62.3
	DR3	73.8	71.3	74.8	74.8	81.0	73.2	76.2	71.6	75.1	73.2	81.5	75.6
	DR3	77.7	73.5	79.2	76.3	80.7	77.1	80.2	74.8	75.5	79.1	86.5	78.8
	NR1	47.7	49.8	48.4	41.0	46.3	52.3	44.8	38.7	45.0	53.2	46.6	42.1
	NR2	58.7	56.5	58.3	57.7	65.1	58.9	58.6	54.6	59.4	58.6	65.2	58.3
	NR3	70.6	66.7	72.6	68.3	76.4	71.0	71.1	66.6	68.4	68.3	77.6	70.0
3	NC2	55.6	47.6	54.0	56.1	48.4	55.3	56.0	49.6	56.0	55.3	48.5	55.0
	NC1	55.3	59.6	55.3	56.1	62.0	56.5	55.0	59.8	56.4	55.6	59.2	55.3
	NC1	53.8	59.7	53.8	54.2	60.5	55.1	54.7	58.6	54.2	53.6	59.2	53.5
	NC2	53.6	45.5	52.5	53.8	45.8	52.7	53.7	46.2	53.3	53.5	46.1	53.4
4	NS3	97.4	96.8	96.8	94.2	57.6	92.0	95.8	96.3	96.8	93.1	59.2	90.9
	NS1	112	112	110	115	114	112	113	118	114	110	114	114
	NS2	76.4	91.7	75.4	77.4	91.4	75.4	75.3	90.7	76.8	75.3	92.4	75.4
	NS3	116	68.6	121	127	126	126	126	77.5	121	128	131	132
5	D1				57.8	63.2	64.7						
	D2	65.1	62.0	61.9									
	D3	64.9	57.9	52.1									
	D4				67.1	60.0	62.3						
6	DR1	54.0	53.8	53.4	46.2	49.6	56.2	50.4	45.4	48.9	56.8	50.6	46.7
	DR3	67.8	63.9	68.0	62.6	73.9	68.2	68.2	61.7	65.6	67.8	75.2	64.7
	DR3	67.7	61.4	65.6	69.8	72.4	69.1	74.2	74.2	74.4	67.8	74.6	71.8
7	NS2	49.5	59.3	48.1	46.3	58.1	48.5	46.9	57.9	46.7	47.1	57.1	46.4
	NS1	78.5	79.3	78.2	77.0	79.1	78.7	76.4	79.0	78.7	76.6	80.4	78.0

From Yonemura et al. (1978).

[1] Direction in which photometer, simulating a typical worker, faces. 0 = photometer directly facing the indicated compass point; R and L = photometer facing 45° to the right and left, respectively, of the indicated compass point.

[2] N = artificial light only, D = artificial light plus daylight; C = checkerboard luminaire spacing, R = continuous rows of luminaires, S = symmetrical luminaire spacing; 1 = directly under luminaire, 2 = centered between 4 luminaires, 3 = centered between 2 luminaires.

Table 3

Contrast Rendition Factors Obtained with Photometric Techniques[1]

Floor	Location[3]	North[2] R	North O	North L	East R	East O	East L	South R	South O	South L	West R	West O	West L
1	NC2	.929	.816	.913	.954	.815	.907	.992	.882	.986	.975	.894	.976
	NC1	.951	.970	.859	.919	.948	.892	.908	.957	.867	.881	.959	.884
	NC1	.897	.982	.961	.946	.988	.925	.946	.952	.925	.940	.917	.965
	NC2	.986	.886	1.012	1.008	.929	.994	.980	.918	1.026	.998	.917	.965
2	DR1	1.010	.987	1.052	1.044	1.033	1.048	1.002	1.037	1.038	1.021	1.045	1.031
	DR3	.981	.890	.954	.955	1.029	.972	1.000	.879	.992	.954	1.015	.920
	DR3	.959	.921	1.053	.970	1.047	.984	.962	.915	9.46	.969	.996	.961
	NR1	.970	.878	.924	1.009	1.007	.959	.954	1.066	.986	.906	.946	.923
	NR3	.889	.890	.821	.865	.974	1.010	.875	.837	.887	.891	.858	.845
	NR3	.921	.827	.917	.877	1.034	.889	.912	.816	.909	.886	.981	.868
3	NC2	1.043	.979	1.051	1.088	.967	1.051	1.027	.987	1.055	1.119	.965	1.033
	NC1	.934	.940	.930	1.019	.935	.940	.918	1.076	.954	.899	.967	.957
	NC1	.939	.911	.922	.939	.948	.943	.947	.968	.919	.969	.911	.928
	NC2	1.011	.976	1.084	1.076	.919	1.070	1.043	.944	1.018	.999	.955	.968
4	NS3	.984	1.004	.968	.999	.641	.914	.937	.983	.984	.991	.641	1.057
	NS1	.901	.875	.866	.874	.845	.880	.916	.852	.885	.959	.867	.937
	NS2	1.004	1.066	1.013	.988	1.059	.983	.993	1.130	.943	.985	1.038	.962
	NS3	1.018	.659	.990	.906	1.002	1.112	.995	.510	1.057	.982	.987	.977
5	D1				.941	.924	.872						
	D2	.899	.976	.645									
	D3	.924	.957	1.023									
	D4				.762	.904	.973						
6	DR1	1.007	.939	1.017	1.045	.995	.995	1.109	1.146	.977	1.021	.961	1.000
	DR3	.935	.856	.952	.921	1.069	.934	.959	.850	.923	.899	1.050	.937
	DR3	.975	1.010	1.027	.871	1.012	1.009	1.069	.886	.972	1.069	.999	.946
7	NS2	.996	1.106	.944	1.020	1.036	.970	1.016	1.046	.980	.999	1.042	1.022
	NS1	.894	.839	.858	.914	.881	.867	.896	.859	.889	.892	.974	.862

From Yonemura et al. (1978).

[1] A no. 2 pencil mark on standard bond paper served as the reference task.

[2] Direction in which photometer, simulating a typical worker, faces. O = photometer directly facing the indicated compass point; R and L = photometer facing 45° to the right and left, respectively, of the indicated compass point.

[3] N = artificial light only, D = artificial light plus daylight; C = checkerboard luminaire spacing, R = continuous rows of luminaires, S = symmetrical luminaire spacing; 1 = directly under luminaire, 2 = centered between 4 luminaires, 3 = centered between 2 luminaires.

Table 4. Heating, Ventilating, and Air-Conditioning Systems in the Norris Cotton Building

Floor	Perimeter Zone	Interior Zone
1	Heating/cooling heat pump, with variable air volume boxes	Heat pump with variable air volume boxes
2	Heating/cooling heat pump, console units under windows	Heat pump with variable air volume boxes
3	Heating/cooling heat pump, with variable air volume boxes	Heat pump with variable air volume boxes
4	Heating, hot water radiation; cooling, variable air volume boxes	Central air handling unit with single duct, variable air volume boxes
5	Heating/cooling double duct, variable air volume boxes	Central air handling unit with single duct, variable air volume boxes
6	Heating/cooling fan coil units	Central air handling unit with single duct, variable air volume boxes
7	Heating/cooling fan coil units	Central air handling unit with single duct, variable air volume boxes

Figure 3. Second floor windows in Norris Cotton Building

Figure 4. Position of blinds in Norris Cotton Building

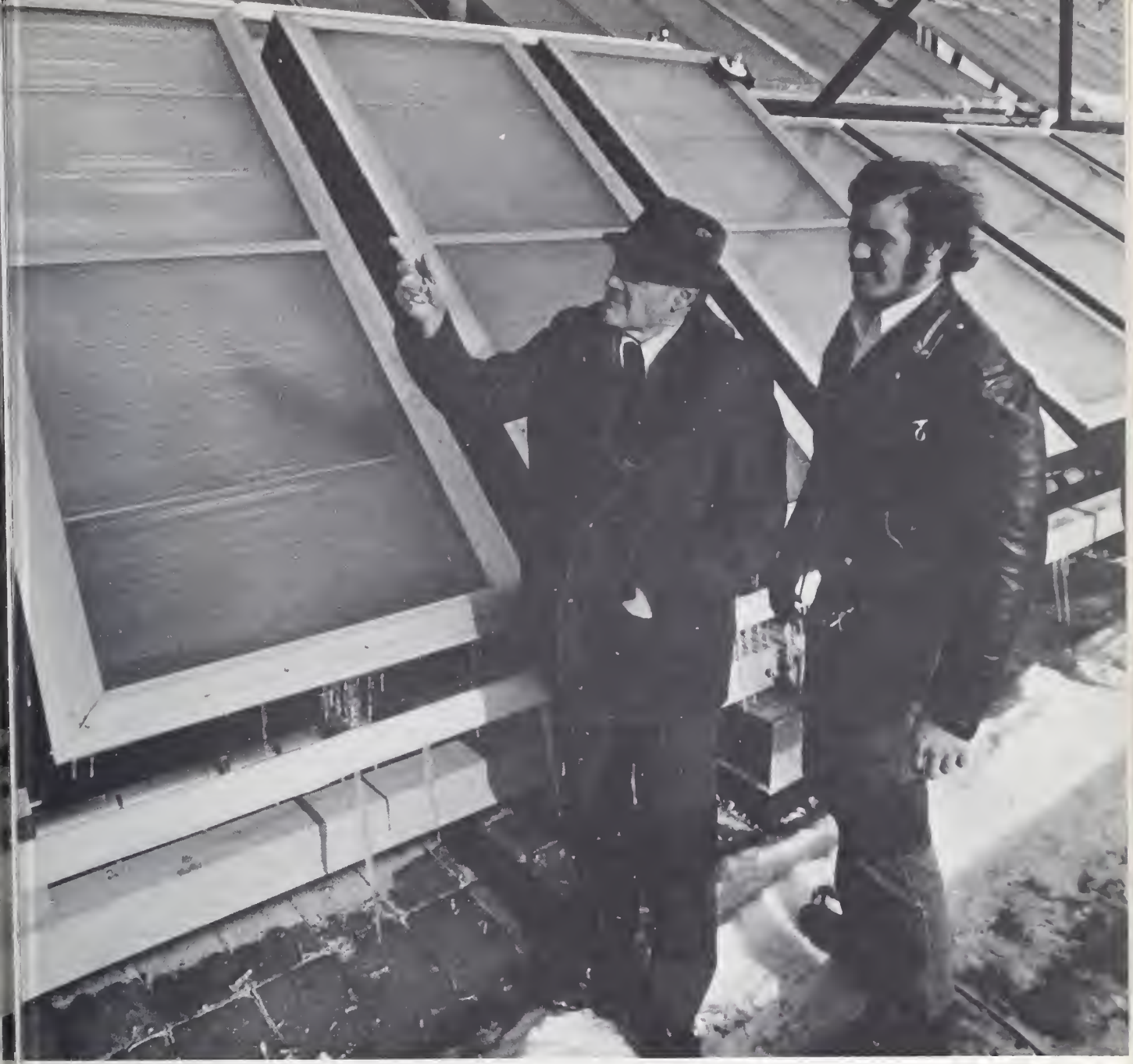
3.2 INTERIOR SPACE OCCUPANCY AND DESIGN

The Norris Cotton Building contains seven floors of office space occupied by various Federal agencies with approximately 400 employees. The first floor is occupied by the Social Security Administration (SSA) with approximately 25 employees; the second and third floors by the Veterans Administration (VA) with a total of about 90 employees; the fourth floor by the Armed Forces Examining Station (AFES) with about 40 employees; the fifth floor by the Department of Housing and Urban Development (HUD) with about 70 employees; the sixth floor by the Internal Revenue Service (IRS) with about 60 employees; and finally the seventh floor has two senators' offices, a congressman's office and several agencies with a small number of employees.

The layout of most areas in the building consists of open-plan offices with a minimum of ceiling-high partitions. An exception is the fourth floor, occupied by AFES, which has been subdivided into medical examination rooms, laboratory space, testing rooms, private offices, and conference rooms. The seventh floor also has been subdivided since several groups are located there.

Facing page:

The tilt angle of the solar collector panels on the Norris Cotton Building can be adjusted to obtain the maximum benefit from the sun.



4. RESEARCH APPROACH

Occupant response to the Norris Cotton Building was assessed in two ways. First, observations were made and selective personal interviews conducted in various agencies prior to their relocation to the Norris Cotton Building. Second, two questionnaires -- one six months after occupancy, the other eight months later -- were sent to all occupants of the building.

The original research plan stressed an examination of the relationships between the subjective response data obtained by means of the

questionnaires and the physical data collected by the sensors located throughout the building. Unfortunately, detailed and consistent physical measurements were not available for the periods during which the questionnaires were administered and only very rough conclusions could be drawn concerning the effect of actual environmental conditions on the occupants.

4.1 OBSERVATIONS AND INTERVIEWS PRIOR TO RELOCATION TO THE NORRIS COTTON BUILDING

In August 1976, observations were made, photographs taken, and interviews conducted at the Internal Revenue Service (IRS), the Veterans Administration (VA), and the Armed Forces Examining Station (AFES) prior to their relocation to the Norris Cotton Building. The interviews covered employee reaction to their then current environment, impressions about the Norris Cotton Building, and attitudes toward the upcoming move. The insights gained in this phase served as a reference for the interpretation of responses to the Norris Cotton Building.

4.2 FIRST MAIL QUESTIONNAIRE

In March 1977, a questionnaire was distributed to every employee in the Norris Cotton Building. By March, the employees had been in the building six months and had experienced a winter in their new offices. Six months was felt to be sufficient time for people to adapt to their new environment and also to ensure that the building environmental control systems were functioning.

The questionnaires were mailed to the chief of each agency. The chief or his representative then distributed a questionnaire to each employee. Prior to the implementation of this procedure a personal interview was conducted with the chief of each agency explaining the purpose of the questionnaire and the involvement of NBS in the evaluation of the Norris Cotton Building. Each questionnaire was accompanied by a cover letter briefly explaining the nature of the project, indicating that anonymity would be maintained, and providing the name of a NBS contact. The respondents could return the completed questionnaires directly to NBS or each agency could collect its questionnaires and return them as a group. Most of the questionnaires were returned in groups by the agencies. Two hundred ninety-two completed questionnaires were returned - a return rate of 75 percent.

The questionnaire was developed using information from existing questionnaires and from the interviews conducted prior to the move. It was pretested at NBS and on a limited basis at the Norris Cotton Building.

The questionnaire had 47 questions and required between 10 and 20 minutes to complete. It began with questions concerning the occupants' general impressions of the Norris Cotton Building. For example: "Is there anything you particularly like about the Norris Cotton Federal Building?" "Would you like to change your present office in any way? If yes, how?" These early questions tended to be open-ended and general in order

to elicit opinions from the occupants without drawing attention to specific environmental attributes. Questions were then asked about more specific topics such as the lighting; noise, particularly as it related to the open-plan offices; the thermal environment; and the windows, especially their size and the view from them.

The questionnaire concluded with "personal" information such as floor number, sex, age category, and general job category. A statement on the questionnaire assured respondents that this information would be used for data analysis only and would not be used to identify individuals. (The initial (March 1977) questionnaire and the accompanying cover letter are reproduced in appendix A.)

4.3 SECOND MAIL QUESTIONNAIRE

The chief of each agency or his representative distributed the second questionnaire to the employees in mid-November 1977. This was after the employees had occupied the building for slightly over a year and had experienced both winter and summer weather conditions.

The second questionnaire was essentially the same as the first. A few questions were eliminated, for example, those asking the employees to compare the Norris Cotton Building with their previous office, and some questions were consolidated. As a result of responses to the open-ended questions on the first questionnaire, a question was added about satisfaction with parking, elevators, eating facilities, and exterior appearance. Sixty percent (230) of the questionnaires were returned. (The second (November 1977) questionnaire and the accompanying cover letter are reproduced in appendix B.)

Facing page:

Windows in the Norris Cotton Building are generally smaller and narrower than in other office buildings.

5. RESULTS

5.1 OBSERVATIONS AND INTERVIEWS PRIOR TO RELOCATION TO THE NORRIS COTTON BUILDING

The Internal Revenue Service (IRS) was located on the ground floor of a building in the center of the shopping area of downtown Manchester (figure 2). The office had a street front entrance with large windows around the perimeter, a cafeteria, and free, readily available street parking.

The interior space was designed with private and semi-private offices around the outside and open-plan offices in the interior area. (Figure 5 shows a photograph of the exterior of the IRS office. Security regulations prohibited interior photographs.)

In general, the IRS interview results indicated that the employees were satisfied with their location and offices (although they were occasionally cold in the winter). They had very practical concerns about moving to the Norris Cotton Building and felt that the new building needed more elevators, more parking, and a cafeteria. The employees also were troubled about moving to the sixth floor and no longer being easily accessible to their clientele. The individuals interviewed had not visited the Norris Cotton Building, but were aware of the solar collectors on the roof. Several of the employees were bothered about the possibility of being located near the blank north wall.

The Veterans Administration (VA) was located in an older building at a far end of town (figure 2). The building had high ceilings, wood panelling, large openable windows, window unit air conditioners, and draperies in most areas. (Photographs of the building and an interior office are shown in figures 6 and 7.)

The employees conveyed the impression that they liked the character and location of the building. Discussion about the move to the Norris Cotton Building brought up concerns about lunch and parking. The employees indicated that although their older building did not have a cafeteria, a number of satisfactory restaurants were located nearby. Also, the building had parking lots to accommodate the entire staff.

The Armed Forces Examining Station (AFES) was located in the same building as the VA (figure 2). (Figure 8 shows one of the old AFES offices.) Several of the individuals interviewed had actually been in the Norris Cotton Building. They disliked the lack of parking and lunch facilities and the extremely small windows. Their main concern, however, was with the lighting system that had been installed. They were to occupy the fourth floor illuminated by high pressure sodium lamps. AFES employs doctors to perform physical examinations on individuals being recruited by the armed services as well as laboratory technicians to analyze blood and urine samples--tasks that include visual evaluation. The AFES commander felt the quality of the light to be provided in the new building was inappropriate for these visual evaluations, in which color discrimination is critical.

5.2 QUESTIONNAIRES

The results of the two questionnaires were analyzed in several ways. First, percentages were calculated for the responses to each item. These data appear in appendices A and B. Responses were then analyzed by floor (appendices C and D), since each floor of the

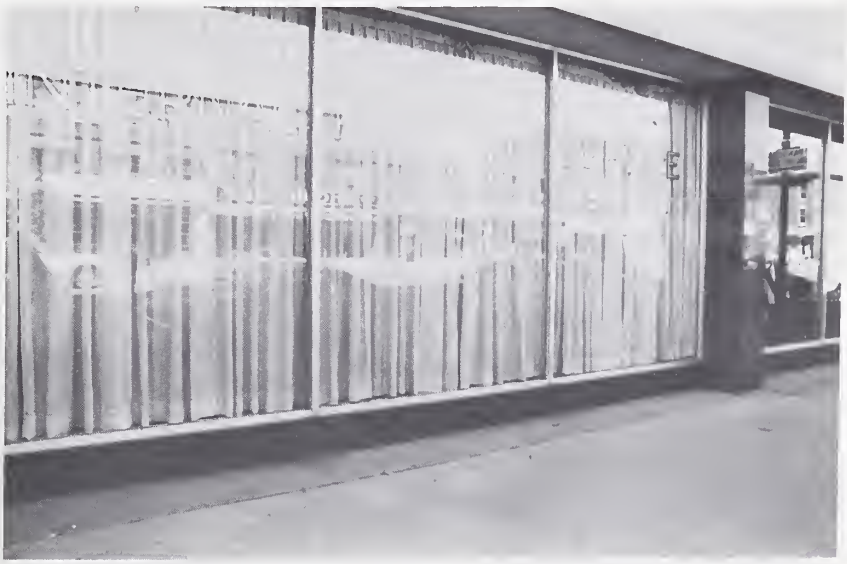


Figure 5. Exterior of building housing previous IRS offices

Figure 6. Exterior of building housing previous VA and AFES offices

Figure 7. Interior of a previous VA office

Figure 8. Interior of a previous AFES office

Norris Cotton Building represents a different physical environment. Questionnaire items were grouped by design feature, and summary tables were developed comparing responses to each feature on the two questionnaires (appendix E). Finally, chi-square (x^2) analyses were performed to identify which differences were statistically significant (beyond the .05 level).

For each questionnaire item, some respondents did not express an opinion or gave inappropriate responses. Usually, only a few responses fell into these categories, especially for the key questions on satisfaction (item 9 of the first questionnaire, item 8 of the second), and it was decided that eliminating these responses from the analysis would not seriously alter the results. Second questionnaire data from the seventh floor are not plotted in the figures reporting individual floor responses because very few completed questionnaires were received from that floor (item 36, appendix B).

5.2.1 General Response to the Norris Cotton Building

In the first part of the questionnaire, employees answered questions concerning their general "likes" and "dislikes" about the Norris Cotton Building, changes desired in their offices, and which features they considered most important in creating a good work environment. Table 5 presents a summary of the major employee "likes" in the building. As table 5 shows, the results of the two questionnaires -- completed six months and 14 months after occupancy of the building -- were essentially the same. Approximately two-thirds of the occupants liked at least one aspect of the building (item 1 of both questionnaires). Location ranked first, being cited as "convenient," "downtown," and "central." Appearance and related aspects such as "newness" and "cleanness" were other positive attributes.

The major "dislikes" are summarized in table 6. On the first questionnaire, 83 percent disliked at least one aspect of the building and on the second questionnaire, 79 percent (item 2 of both questionnaires). The main problems identified by the building's occupants were:

- The temperature was considered to be too cold and too variable.
- The elevators were too slow and unreliable.
- The amount of parking space available was inadequate.
- The windows were too small, there were too few of them, and they could not be opened.

Table 5. Summary of Occupant "Likes"

First Questionnaire (N = 265)	Number	%	Second Questionnaire (N = 213)	Number	%
Location	55	21	Location	60	28
Appearance	38	14	Appearance	29	14
Newness	24	9	Newness	16	8
Cleanness	18	7	Lighting	15	7
Atmosphere	17	6	Atmosphere	13	6
Design	11	4	Cleanness	12	6

Table 6. Summary of Occupant "Dislikes"

First Questionnaire (N=265)	Number	%	Second Questionnaire (N=213)	Number	%
Temperature	85	32	Temperature	105	49
Elevators	70	26	Elevators	39	18
Parking	48	18	Parking	37	17
Windows	47	18	Ventilation	31	14
Ventilation	45	17	Windows	26	12
Lack of cafeteria	35	13	Lighting	23	11
Heavy front doors	30	11	Lack of cafeteria	21	10
Lighting	29	11	Heavy front doors	16	7

- The amount of ventilation was excessive during the heating season and inadequate during the cooling season.

- The building had no cafeteria.

- The front entrance doors were too difficult to open, particularly for the handicapped and elderly people who often visited the Social Security Administration offices in the building.

- The lighting on the fourth floor distorted colors, caused annoying glare, and provided illumination levels which were perceived to be too low.

Complete lists of the "likes" and "dislikes" reported on both questionnaires are contained in appendices F and G. Most respondents said they would like to change one or more aspects of their offices (item 4 of both questionnaires). On both questionnaires, the most often mentioned changes desired were better temperature regulation, more privacy (especially on the second and fifth floors), and greater window area. Other changes desired were better lighting (on the fourth floor), more space, and less noise.

"Comfortable temperature" and "good light" were felt to be the two most important physical features that determine the quality of the office environment (item 8 of the first questionnaire, item 7 of the second). All other features listed were considered much less important, though each was mentioned by at least 10 percent of the respondents.

5.2.2 Response to Specific Design Features

Response to six features -- lighting, noise, odor, ventilation, temperature, and windows -- was examined in detail. Figure 9 summarizes the response to these features. "Percent satisfied" is the percent who said they were either "very satisfied" or "somewhat satisfied" with the particular feature on item 9 of the first questionnaire (item 8 of the second). As figure 9 shows, the overall response to the lighting, odor, and noise level was relatively positive, and to the temperature, ventilation, and window size, negative. There were, however, a number of differences in response to the various design alternatives tested in each of these areas. These differences will now be considered.

5.2.2.1 Lighting

On both questionnaires, lighting was the most satisfactory design feature in the building. In addition, there was a statistically significant increase in the number of persons who were satisfied with the lighting on the second questionnaire (73 percent) as compared with the number satisfied on the first questionnaire given eight months earlier (62 percent). Follow-up questions on light levels, color rendition,

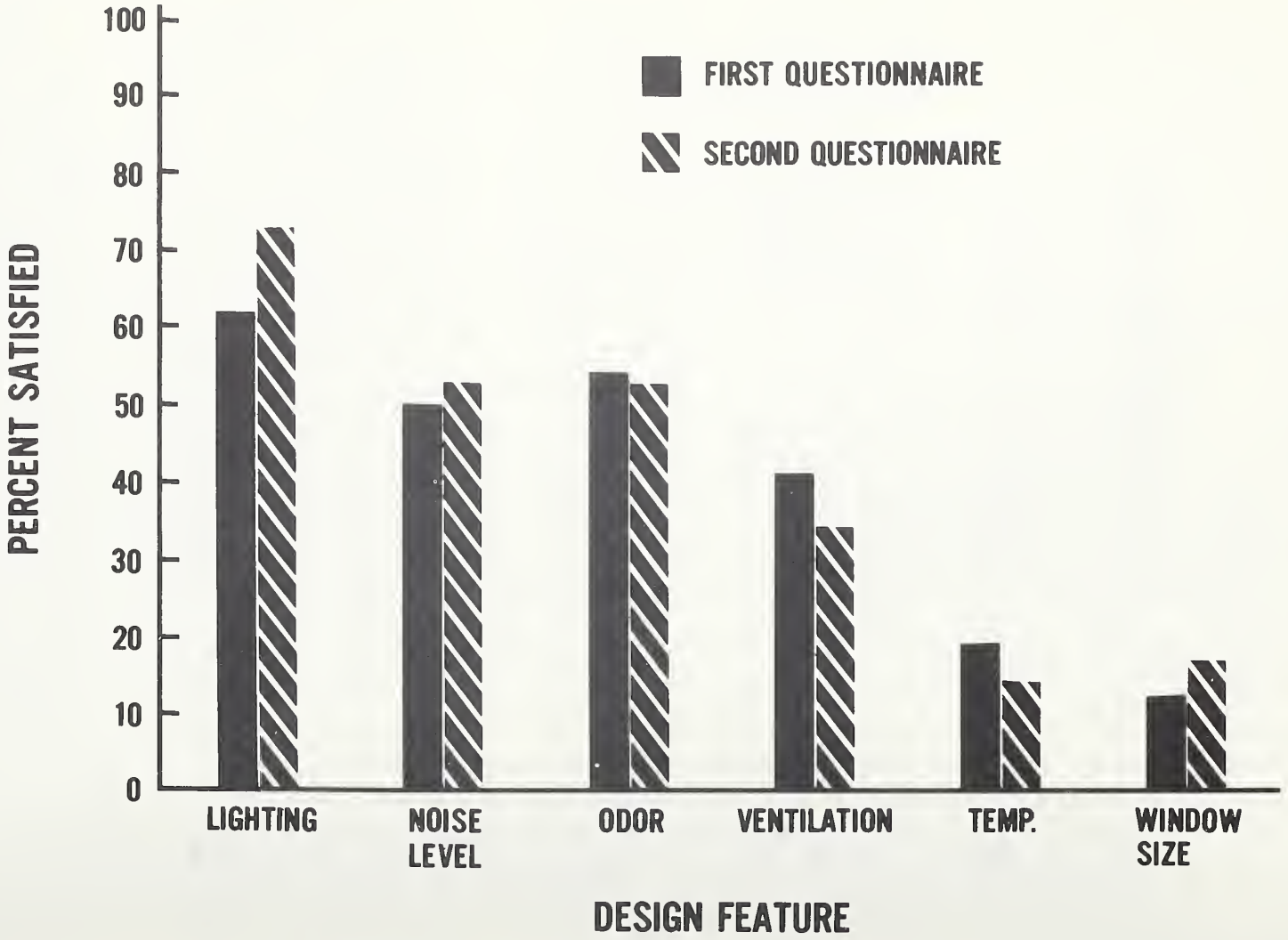


Figure 9. Percent of respondents satisfied with various design features

and glare (items 20-23 of the first questionnaire, and items 18-21 of the second) also yielded generally favorable opinions on both questionnaires, with no statistically significant shifts in response over the eight month interval between the questionnaires.

Figure 10 shows, however, an obvious lack of satisfaction with the high pressure sodium lighting system as it was installed on the fourth floor. Despite the fact that the illumination levels on the fourth floor were generally among the highest in the building (table 2), most persons there felt that they had "too little light" to work by (item 20 of appendix C, and item 18 of appendix D). By contrast, occupants of other floors where the illumination levels were generally much lower perceived the amount of light as "about right." Many people also felt that the high pressure sodium system distorted colors and caused annoying glare (items 21-23 of appendix C, and items 19-21 of appendix D). As table 3 shows, some unusually low contrast rendition factors were recorded on the fourth floor. This could be expected to produce complaints of poor task visibility if the placement of work stations was not carefully considered. More fourth floor occupants complained of headaches and eyestrain than did occupants of other floors.

Response to the first and second floor lighting systems, on the other hand, was consistently quite positive. On both questionnaires over 80 percent of the respondents on these two floors were satisfied with the lighting. Both floors have uniformly spaced fluorescent lighting, with added daylight on the second floor. Tables 1-3 give details on each of these systems, including both quantitative and qualitative measurements of lighting effectiveness (illumination levels and contrast rendition factors, respectively).

Task lighting was built into each fifth floor work station, thereby concentrating light in those areas where it is needed. A description of this system is provided in section 3.1.1. Despite the fact that this system is quite different from those installed on the other floors, user satisfaction with the lighting was neither unusually high nor low compared with the other systems in the building (item 9a of appendix C, and item 8a of appendix D).

Two other comparisons between systems were made. The second and the sixth floors have identical lighting systems, with the exception that on the second floor horizontal windows near the ceiling provide more daylight (figure 3), and photoelectric switches shut off some of the artificial lights when natural light levels reach a certain level (see section 3.1.1). Statistical analyses revealed that on both questionnaires the second floor system (with about 90 percent satisfied) was significantly more satisfactory than the sixth floor system (about 60 percent satisfied).

Identical luminaires were installed on the first and third floors but different lenses (originally prismatic on the first floor, polarized on the third) were placed in them. In June 1977, the lenses were

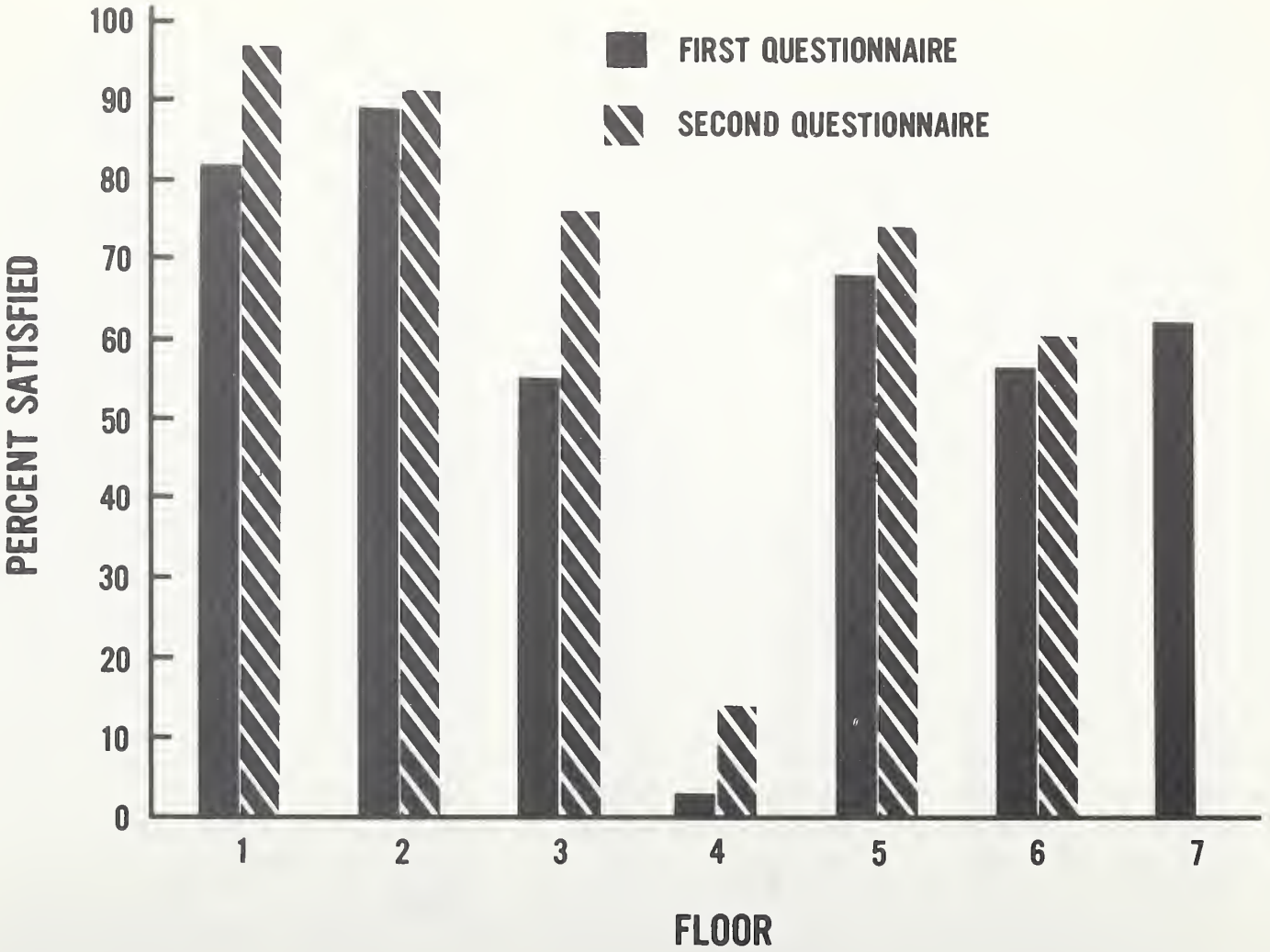


Figure 10. Response to the question, "About how satisfied are you with the lighting of your office?"

interchanged in order to determine whether the polarized lenses had been responsible for the lower level of satisfaction initially observed on the third floor. On the second questionnaire, administered in November 1977, however, satisfaction increased substantially on both the first and third floors (figure 10). Thus no conclusions can be made about the relative acceptability of the prismatic and polarized lenses based on these data.

5.2.2.2 Noise

Although 50 percent of the respondents on the first questionnaire were satisfied with the noise level in their offices, 42 percent were dissatisfied. On the second questionnaire 53 percent were satisfied, and 35 percent dissatisfied with the noise level. On both questionnaires more than 60 percent said their offices were never too noisy to work in (item 17 of the first questionnaire and item 15 of the second), although 39 percent thought there was more noise in their present office than in others they had worked in, while only 26 percent thought there was less (item 16 of the first questionnaire). Voices were the most "noticeable" type of noise (item 18, first questionnaire) and the most "bothersome" (item 16, second questionnaire). Telephones and office machines ranked second and third.

A comparison of the noise climate in the open-plan and partitioned offices in the building revealed statistically significant differences in user response in terms of both the level of noise and its distractiveness (figures 11 and 12). On the first questionnaire, employees in open-plan offices were more dissatisfied with the noise level and had experienced more difficulty in working because of noise. Although there was not a statistically significant difference in satisfaction with the noise level on the second questionnaire, the difference in the extent of work disruption due to noise persisted.

In contrast to most of the floors, the sixth floor response to noise was very negative. On both questionnaires, less than 20 percent of the sixth floor occupants were satisfied with the noise level (figure 13). Nearly 90 percent said their current office was noisier than the last one they had (item 16, first questionnaire); no one found it quieter. Employees stated that the source of the noise problem was "white noise" or "ventilation system noise" (item 18 of the first questionnaire, item 16 of the second). The sixth floor originally had white noise generators but occupant complaints caused them to be turned off after an undetermined length of time.

On two floors there was a statistically significant change in satisfaction between the first and second questionnaires. On the fifth floor, it increased from 29 percent to 53 percent; on the second floor, it decreased from 64 percent to 45 percent. The reasons for these shifts are not clear, but may be related to the fact that white noise generators were initially installed on both of these floors, as on

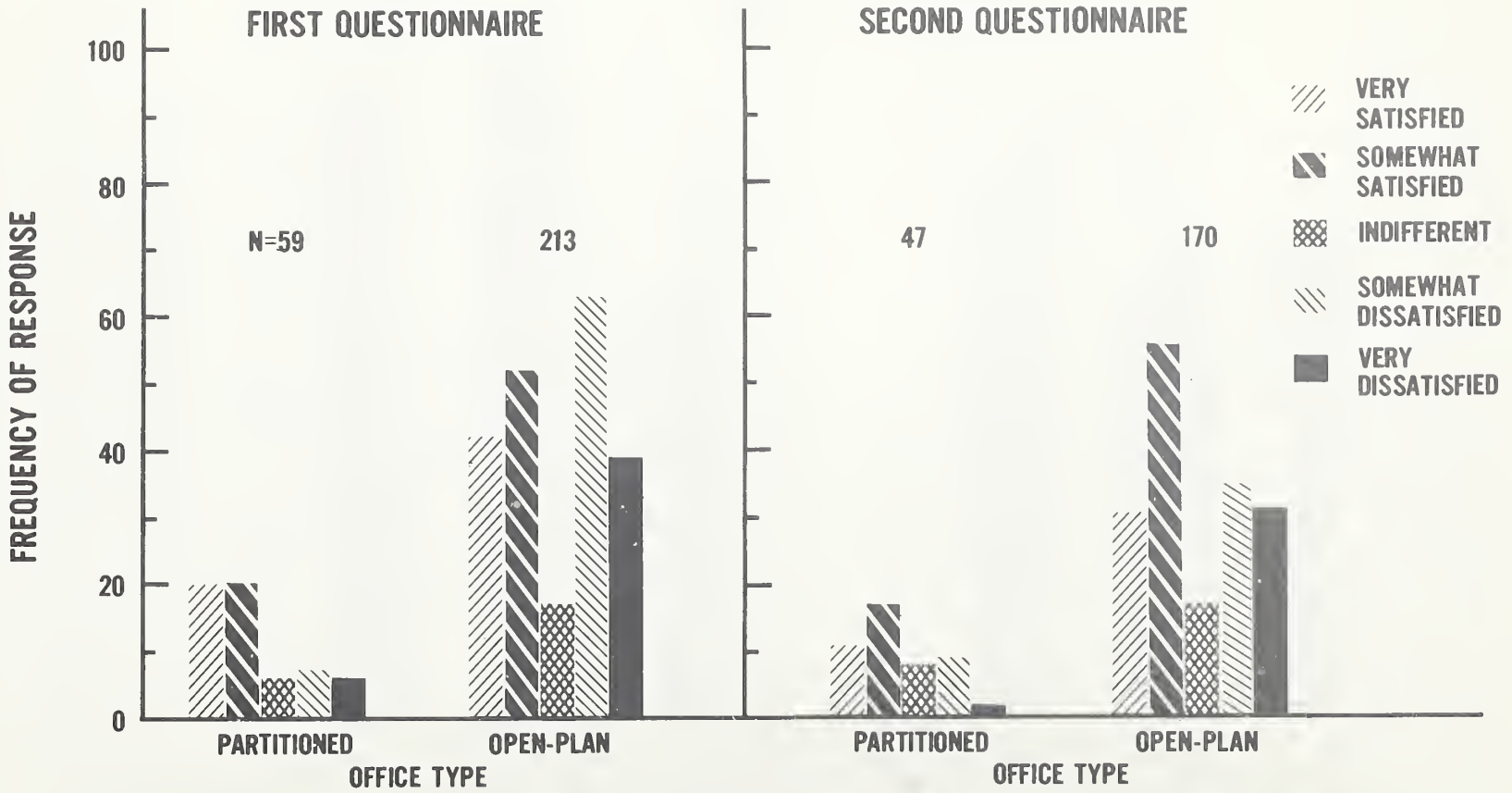


Figure 11. Response to the question, "About how satisfied are you with the noise level of your office?" as a function of office type

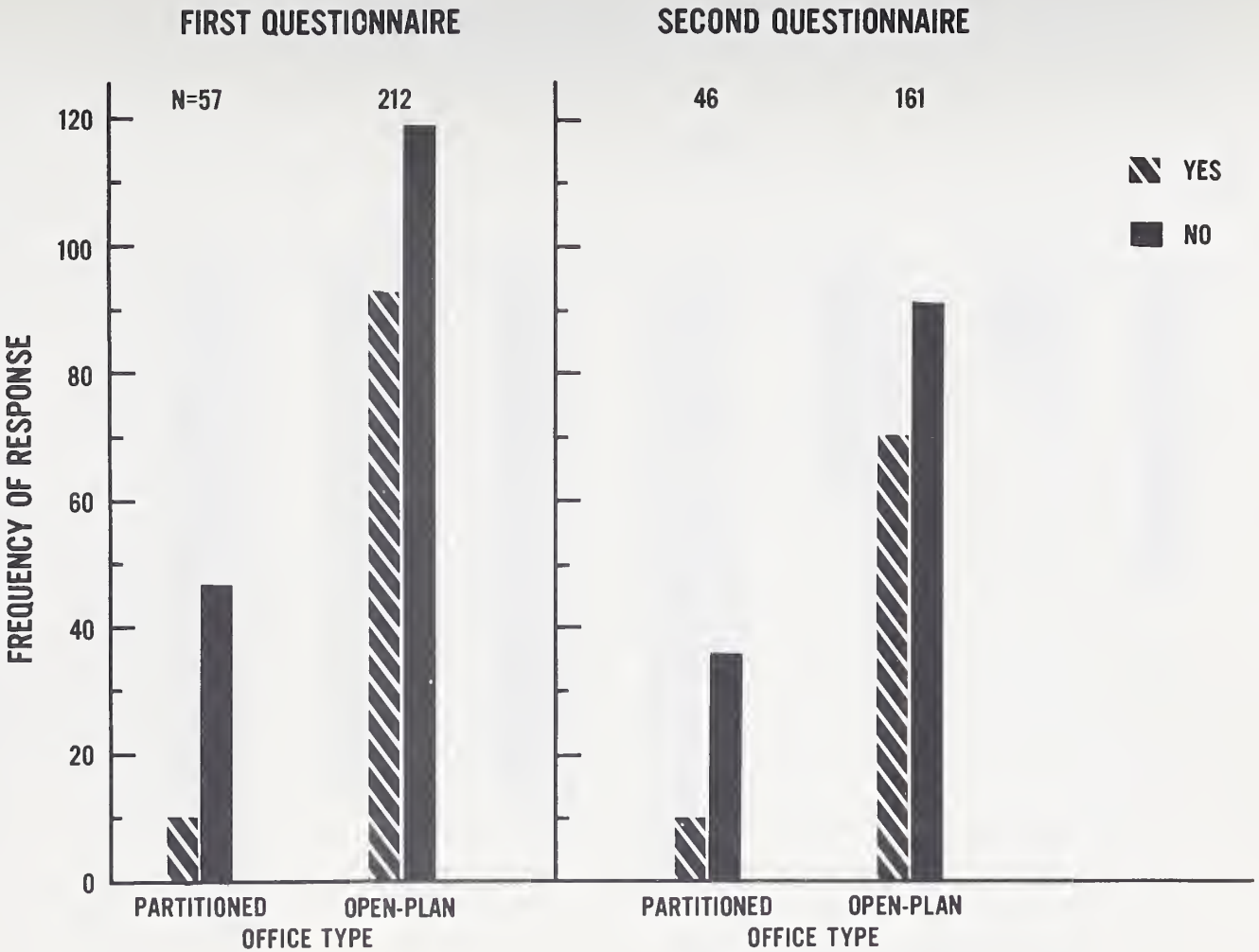


Figure 12. Response to the question, "Does your office ever become so noisy that you find it difficult to work?" as a function of office type

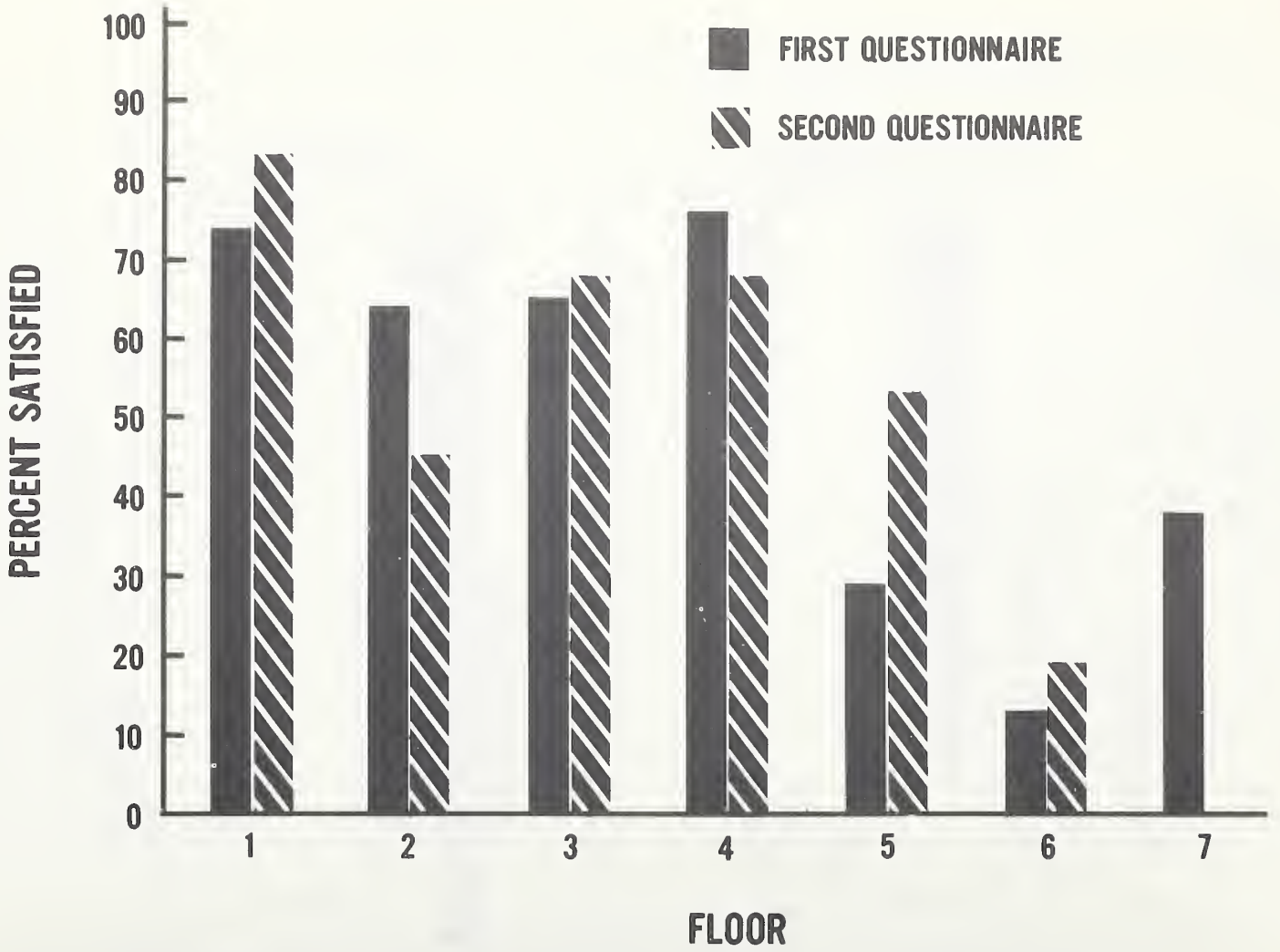


Figure 13. Response to the question, "About how satisfied are you with the noise level of your office?"

the sixth floor, but were also turned off at an undetermined time on all but the east side of the second floor because of complaints by the occupants.

5.2.2.3 Odor

The response to odor was characterized by both satisfaction and indifference. While slightly more than half of the employees were "very" or "somewhat" satisfied with the odor of their offices (figure 14), about one-third were "indifferent" (item 9c of the first questionnaire, and item 8c of the second). Only 10 percent on the first questionnaire were dissatisfied, and 15 percent on the second. On the second questionnaire there was an increase in the number of persons who "often" or "sometimes" noticed unpleasant odors in their offices (from 16 percent to 26 percent), however, odor remained a relatively minor problem.

On both questionnaires, there was a statistically significance difference between floors one through three, outfitted with heat pump HVAC systems, and floors four through seven, serviced by central equipment systems, in terms of satisfaction with odor. In both instances, respondents on floors one through three reported relatively more "very satisfied" and "somewhat satisfied" responses and fewer "indifferent" responses (figure 15). Satisfaction was particularly low on the sixth and seventh floors. These findings are explainable in light of the physical measurements of air leakage in the building made in February 1977, which showed that the rate at which air (and hence odor) was expelled from the building and replaced by fresh air from the outside was much higher on floors one through three than on floors four through seven (section 3.1.2). This does not necessarily mean, however, that the heat pump systems were superior to the central equipment systems in dissipating odor, since the rate of air leakage is typically higher on the lower floors of a building due primarily to the frequent opening of outside doors and the stack effect.

5.2.2.4 Ventilation

On the first questionnaire response to ventilation was mixed, with nearly equal amounts of positive and negative sentiment (41 percent satisfied, 43 percent dissatisfied). Following the summer months, however, there was a general decline in satisfaction (34 percent satisfied, 53 percent dissatisfied), and an increase in the number of persons who "often" felt "uncomfortably stuffy" from 22 percent to 32 percent (item 12 of the first questionnaire and item 11 of the second).

The decrease in satisfaction on the second questionnaire was found in varying degrees on all floors (figure 16). Some individuals mentioned that there was poor air circulation in the building during the summer. Many respondents were also bothered by cold drafts from the ventilation systems, particularly during the winter months on the second and third floors.

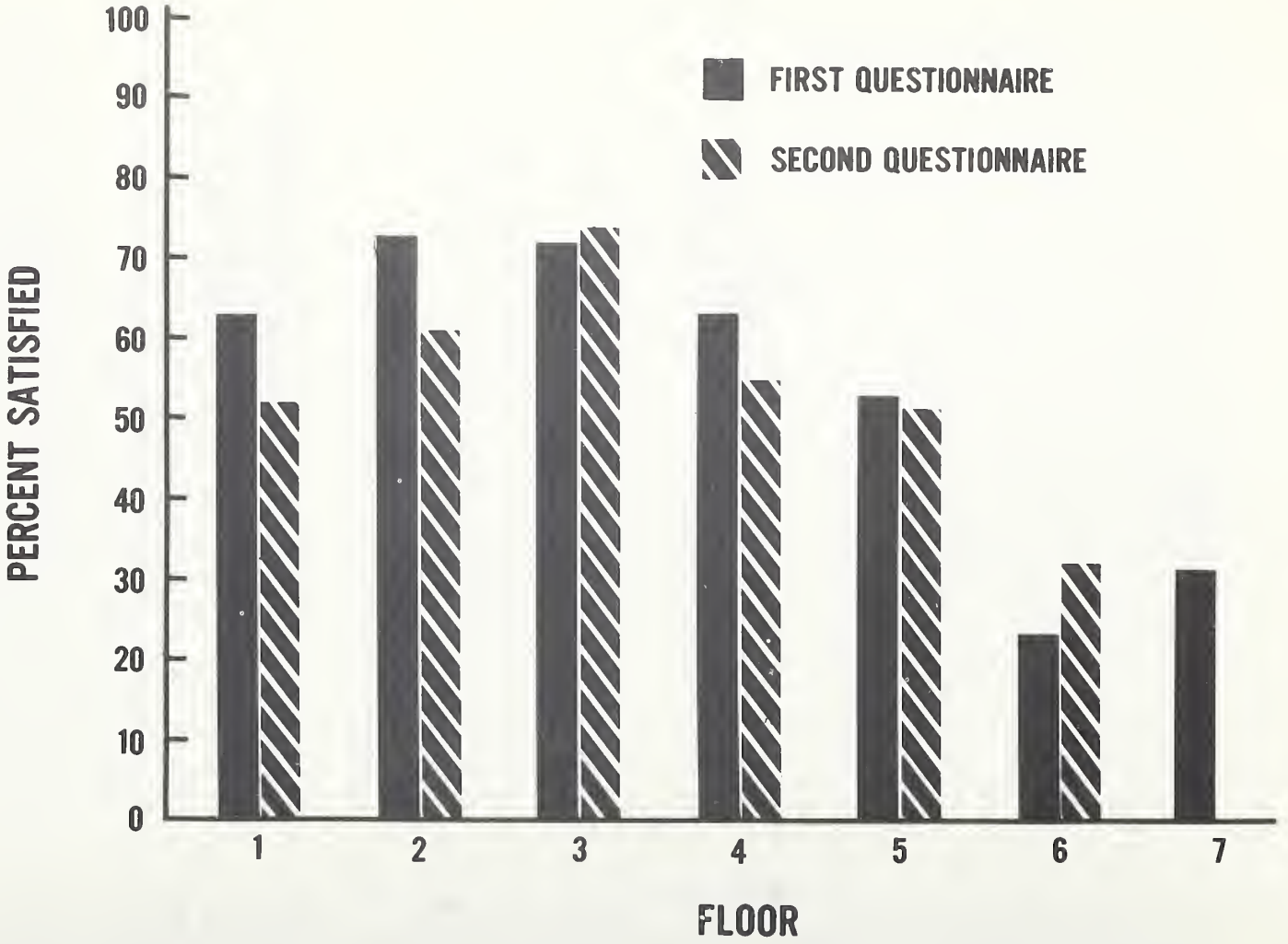


Figure 14. Response to the question, "About how satisfied are you with the odor of you office?"

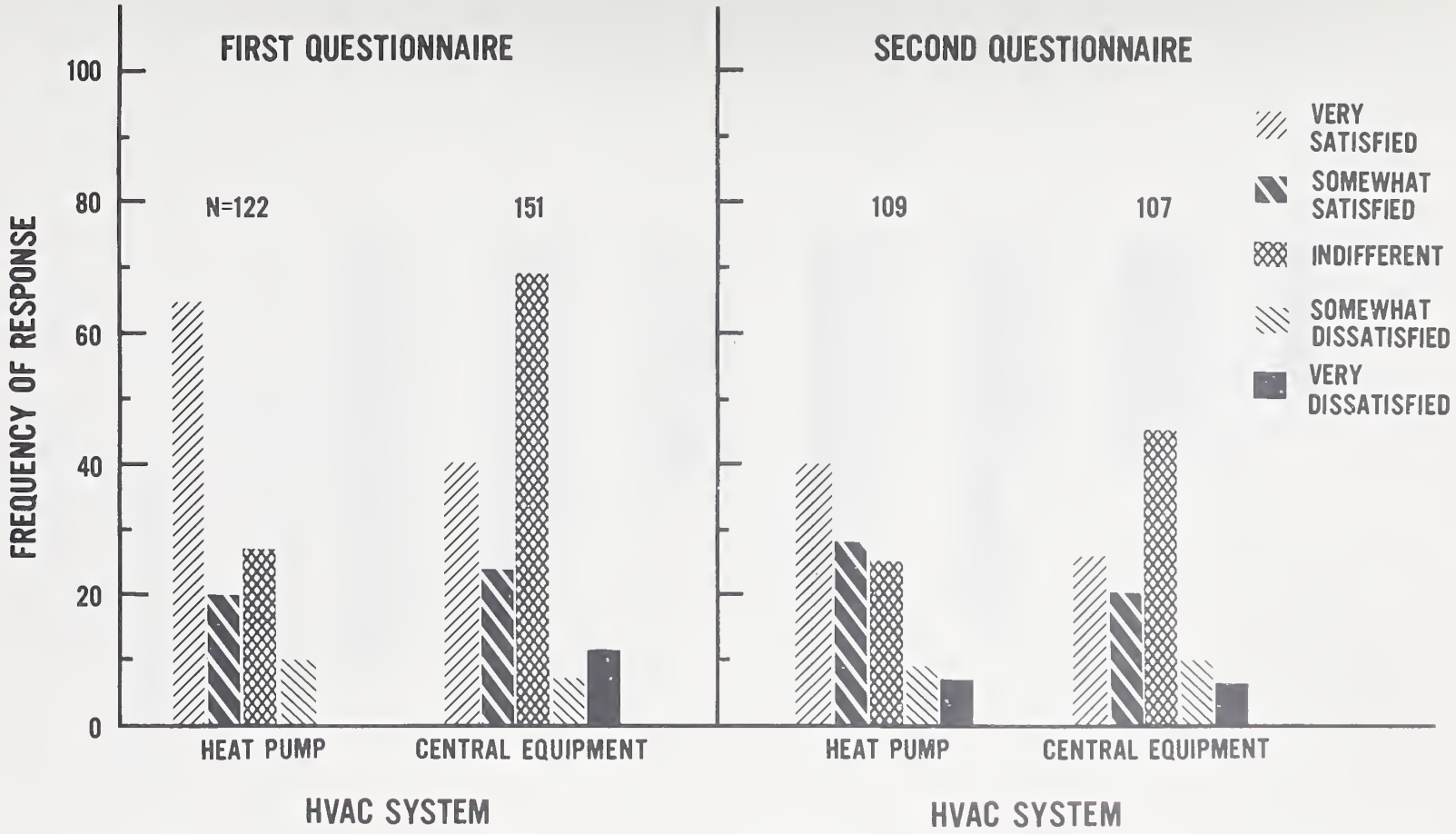


Figure 15. Response to the question, "About how satisfied are you with the odor of your office?" as a function of type of HVAC system

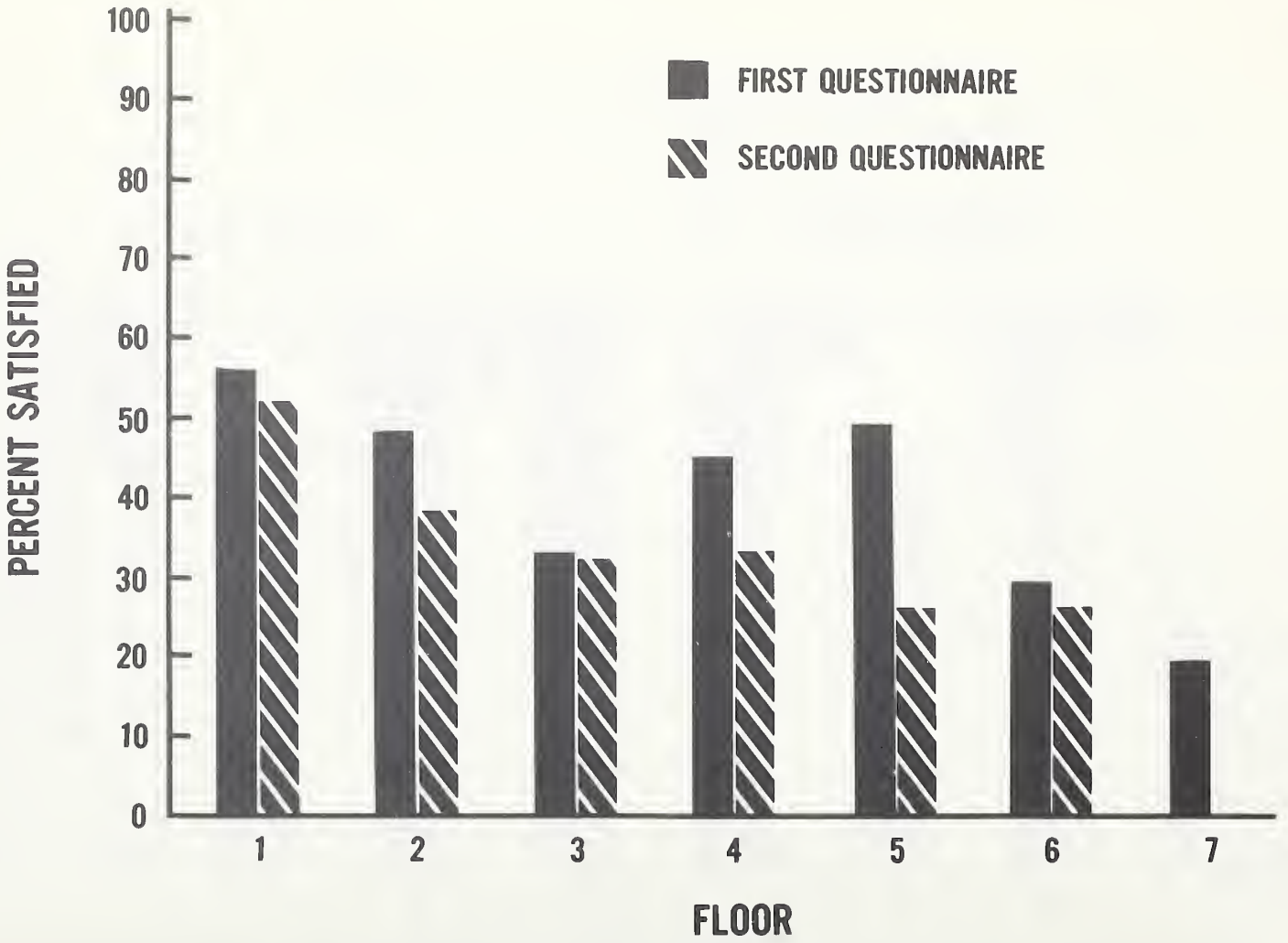


Figure 16. Response to the question, "About how satisfied are you with the ventilation of your office?"

A statistical comparison of the response on floors one through three with the response on floors four through seven revealed no difference in satisfaction with ventilation on either questionnaire (figure 17). On the second questionnaire, however, after summer conditions had been experienced, feelings of stuffiness were significantly more common on floors four through seven than on floors one through three (figure 18). These data, like the odor data, are in agreement with the physical data on air leakage; however, this implies nothing about the subjective acceptability of the different types of HVAC systems for the same reason mentioned earlier (section 5.2.2.3).

5.2.2.5 Temperature

Occupant response to temperature in the building was extremely negative on both questionnaires and on all floors (figure 19). On the first questionnaire, 75 percent were dissatisfied with the temperature of their offices; on the second questionnaire, 83 percent. Over 80 percent on both questionnaires reported that they were "often" or "sometimes" uncomfortably cold (item 10 of the first questionnaire and item 9 of the second). As figure 20 shows, persons on floors one through three were more often bothered by cold temperatures than persons on floors four through seven. This was especially a problem for occupants of the second and third floors. Overheating was also a problem, particularly during the summer on the fourth through the seventh floors (figure 21). Some persons were bothered by fluctuations in temperature during the course of the day, while others noted variations depending on the location within an office. The latter complaint was most common on the first three floors, where cold drafts near windows were a problem (item 32, appendix C, and item 30e, appendix D). These results are consistent with the results of the thermographic measurements of the building, which showed more cold surfaces on the first three floors than on the other floors, particularly on the east and west exterior walls (section 3.1.2).

5.2.2.6 Windows

The windows in the building were a very negatively perceived design feature (figure 22). Only 12 percent of the respondents on the first questionnaire and 17 percent on the second were satisfied with the size of their windows. More than 80 percent thought the windows were too small (item 34 of the first questionnaire, item 26 of the second) and that they offered an insufficient view of the outside world (item 27 of the first questionnaire, item 28 of the second). The windows were perceived as being "poorly proportioned," "narrow," and "irregular" (item 27 of the second questionnaire). Cold drafts near windows were "often" a problem for 30 percent of the respondents on the first questionnaire (item 32) and 25 percent on the second (item 30e). Very few people had experienced problems with glare, overheating, or outside noise from their windows (items 30, 31, and 33 of the first questionnaire, and items 30a, 30d, and 30b of the second). A comparison of floors shows that the level of satisfaction was consistently low, although there was more variability among floors on the second questionnaire (figure 22).

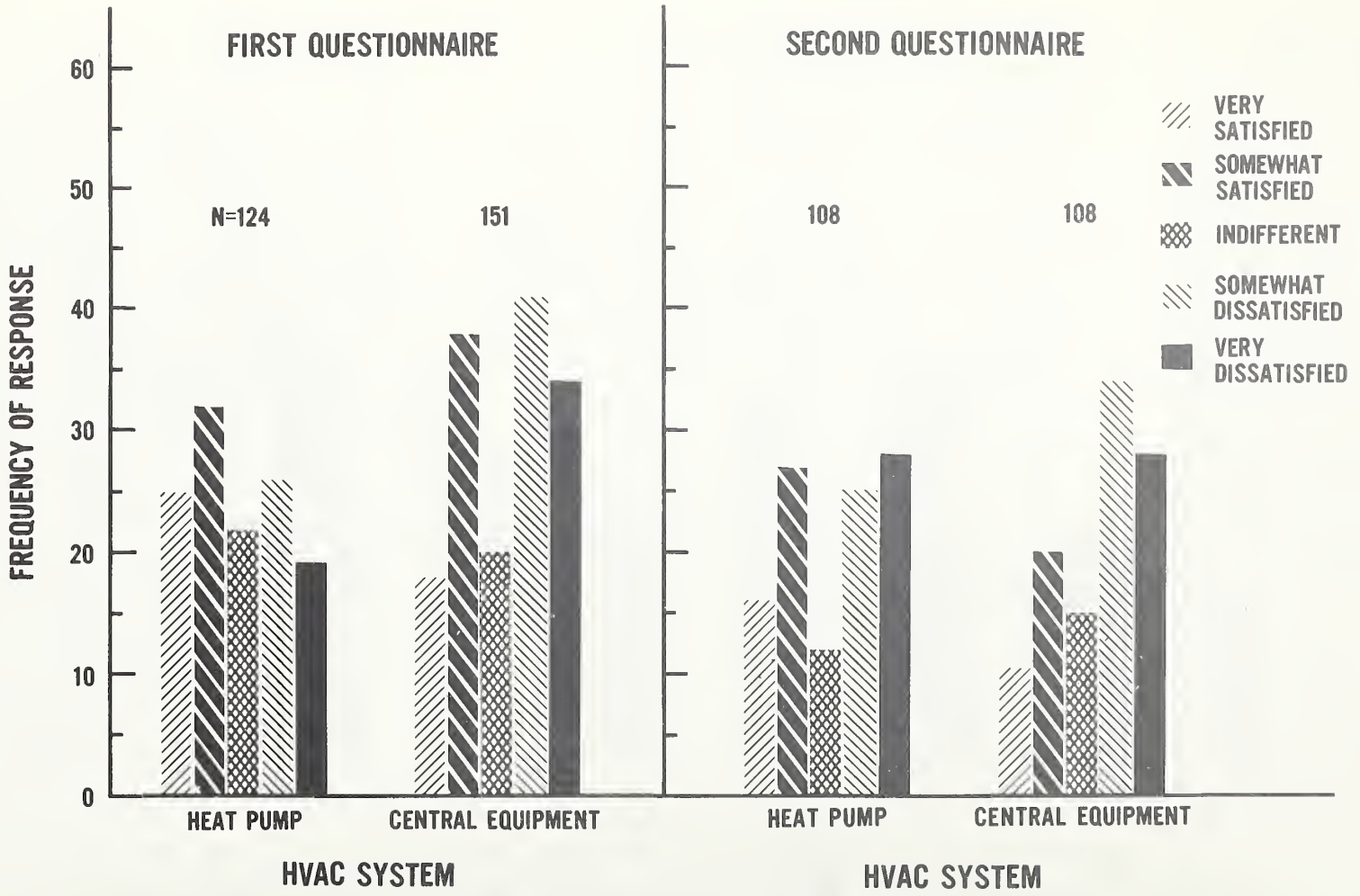


Figure 17. Response to the question, "About how satisfied are you with the ventilation of your office?" as a function of type of HVAC system

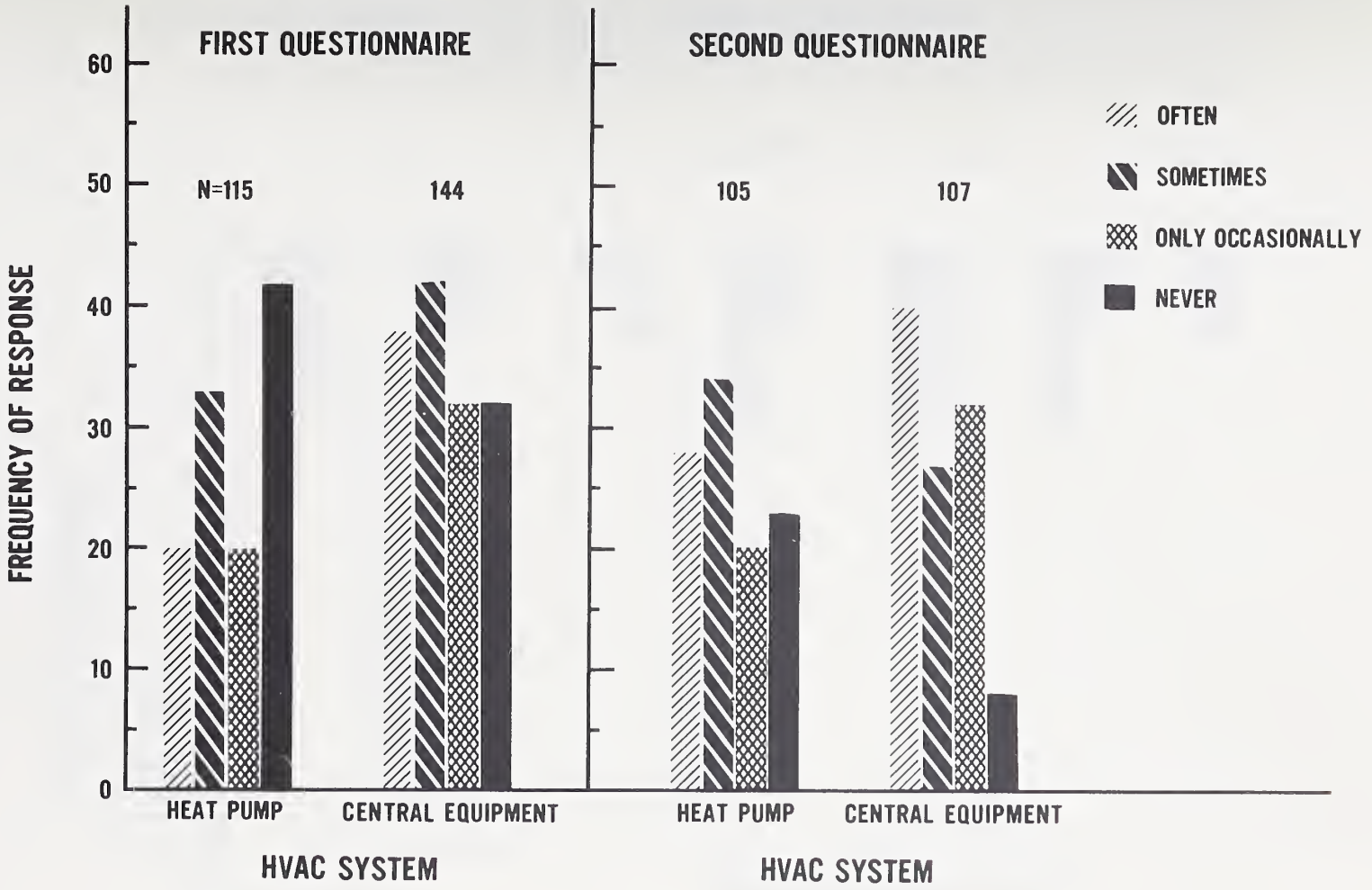


Figure 18. Response to the question, "Does it ever seem uncomfortably stuffy?" as a function of type of HVAC system

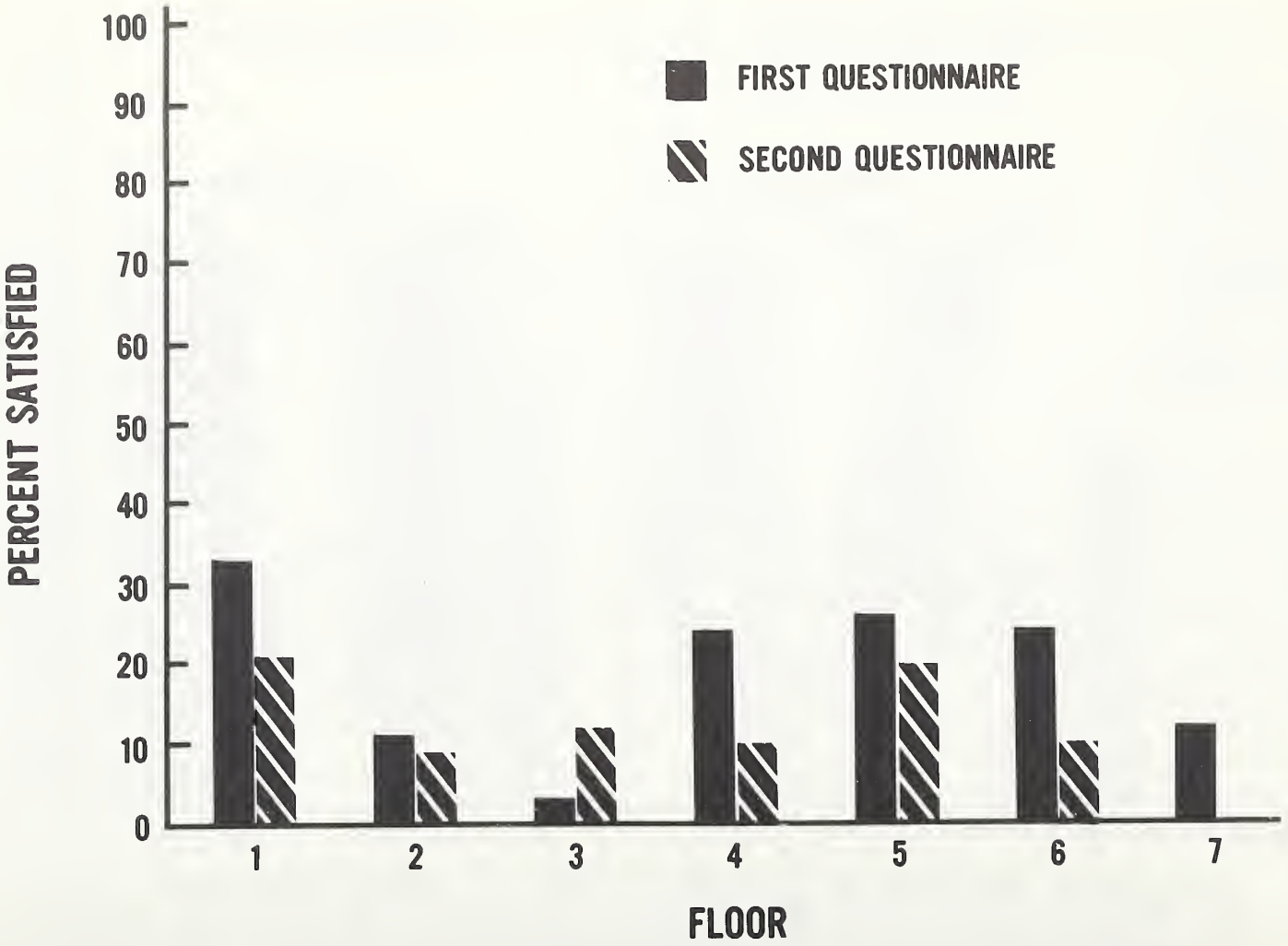


Figure 19. Response to the question, "About how satisfied are you with the temperature of your office?"

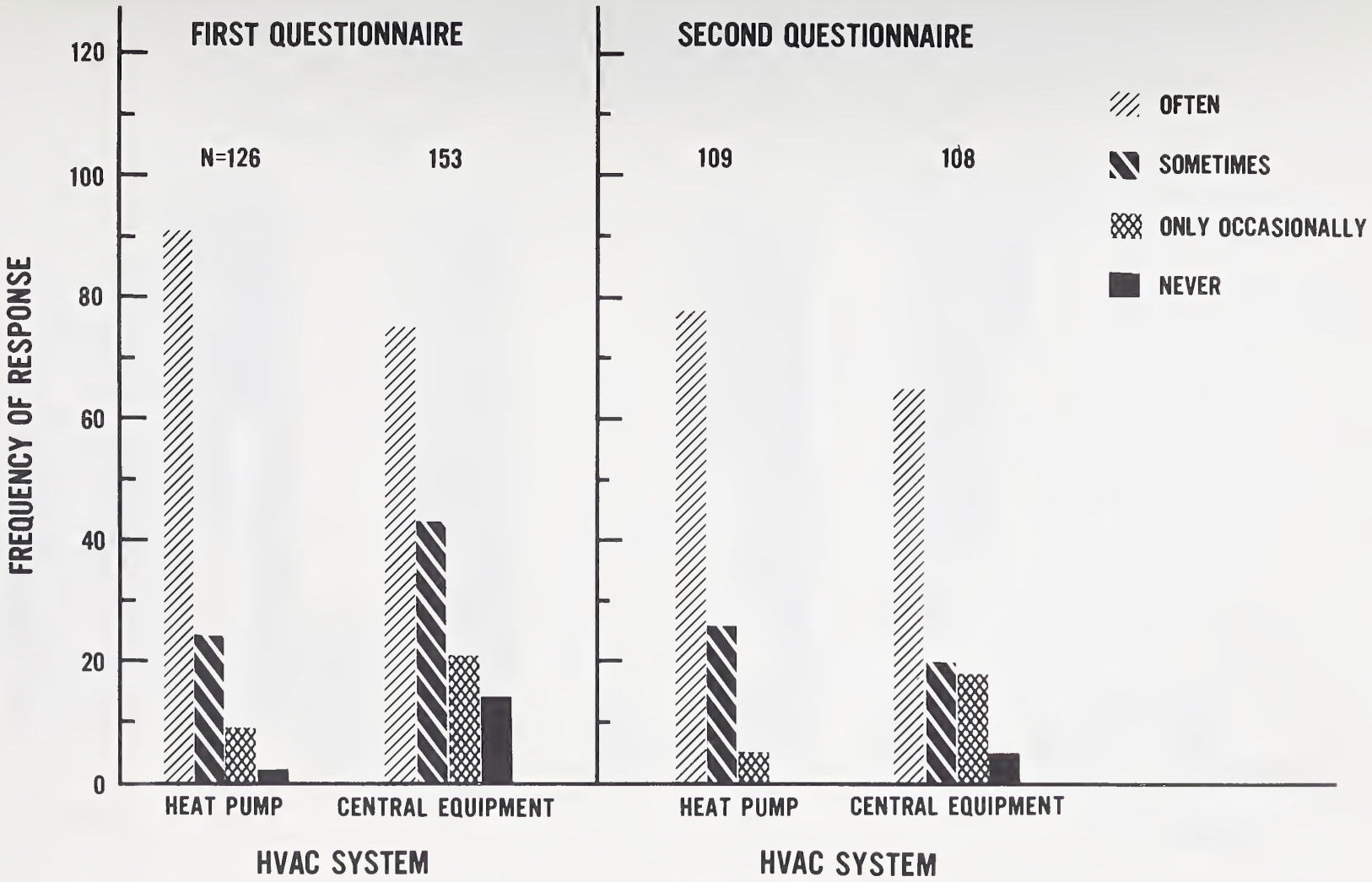


Figure 20. Response to the question, "Does it ever get cold enough to make you feel uncomfortable?" as a function of type of HVAC system

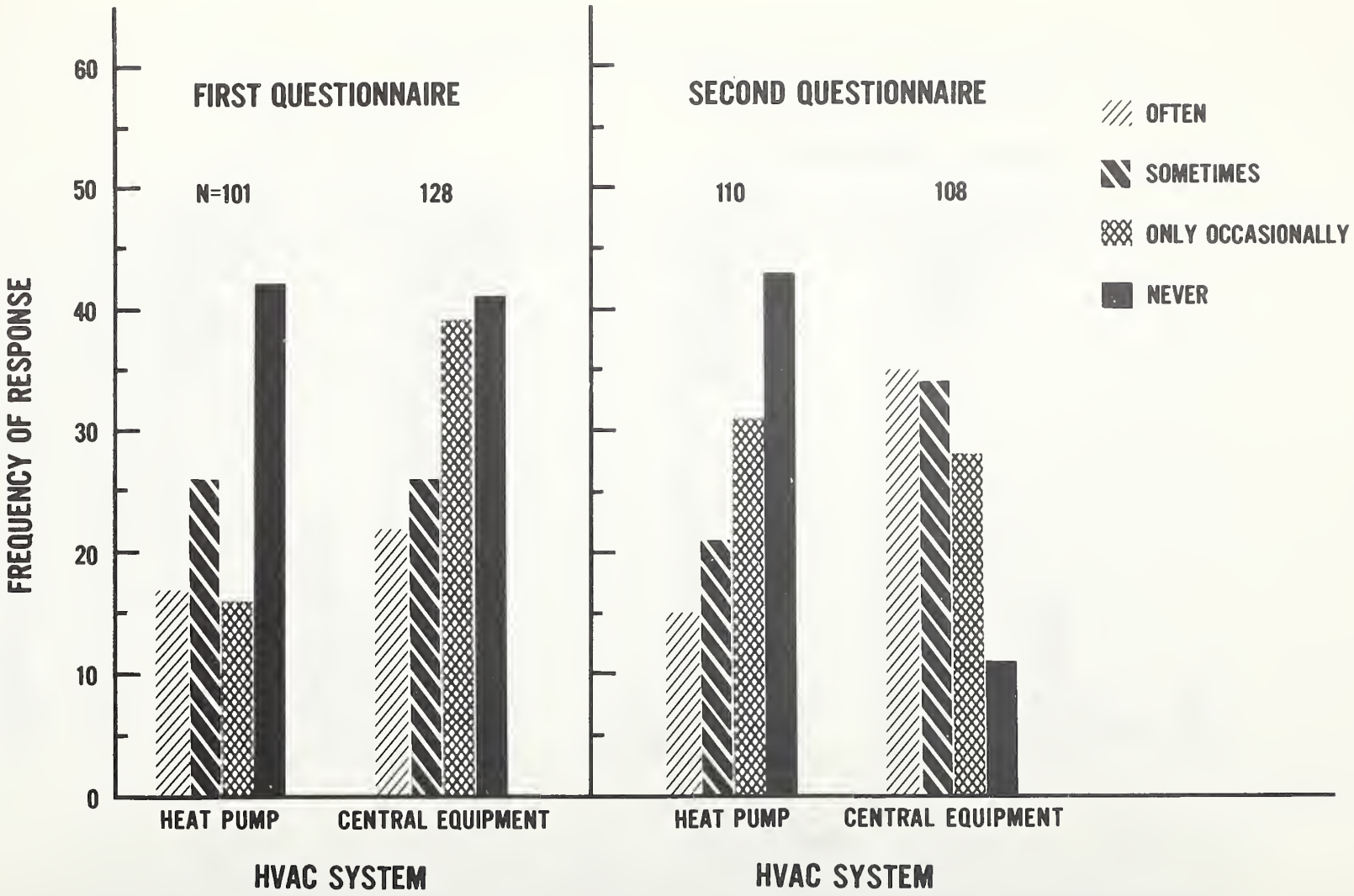


Figure 21. Response to the question, "Does it ever get warm enough to make you feel uncomfortable?" as a function of type of HVAC system

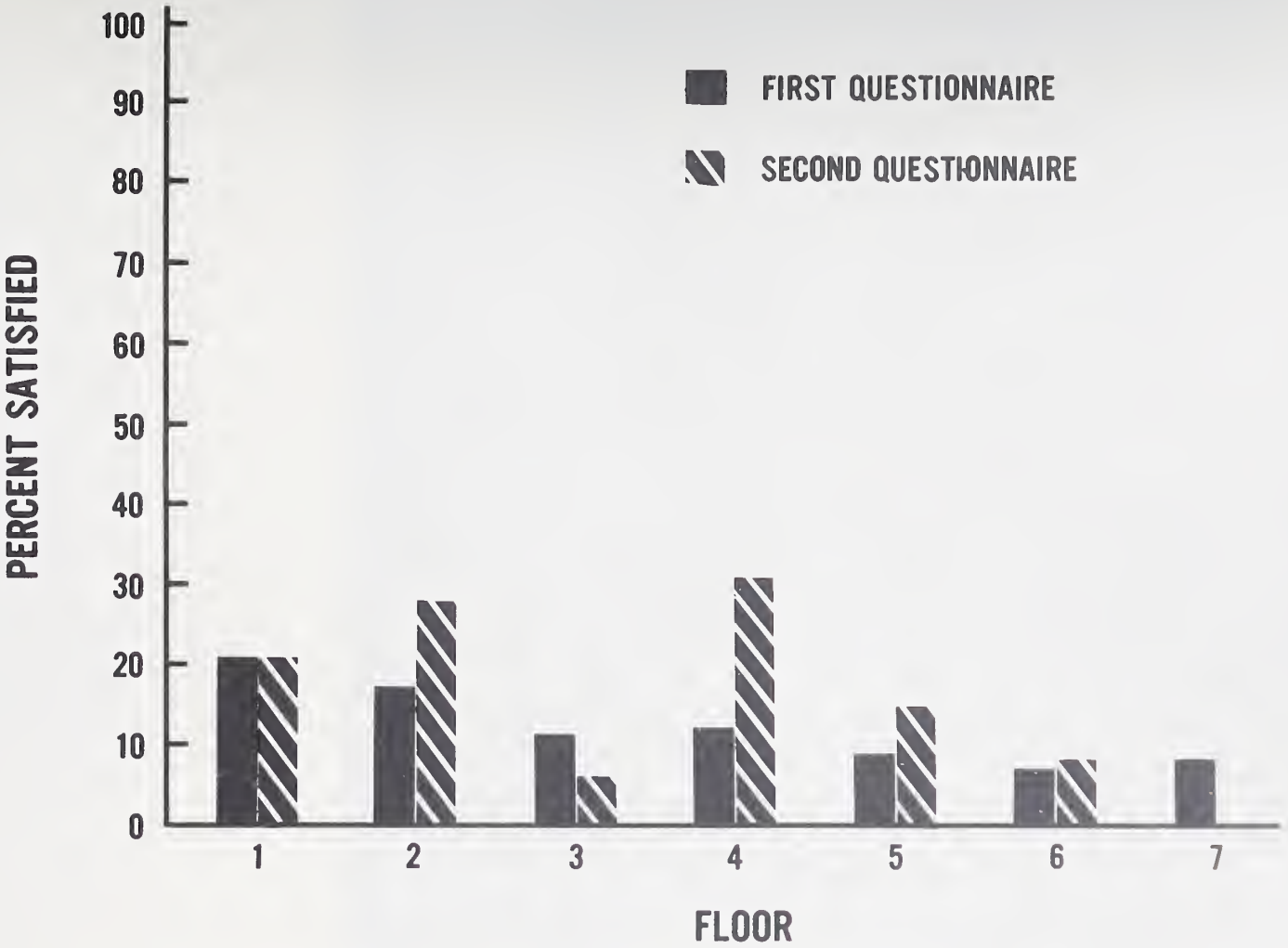


Figure 22. Response to the question, "About how satisfied are you with the window size of your office?"

From a design standpoint, a comparison of the response on the second floor with that on the others is of interest, in order to assess the effect of its larger window area (12 percent of the east, west, and south exterior walls, as compared with six percent on the other floors) on user satisfaction. As figure 22 shows, satisfaction with the size of the windows on the second floor was greater than the average for the other six floors but was exceeded by the first floor on the first questionnaire and the fourth floor on the second. Floor-by-floor analysis of related questions on both questionnaires shows that the second floor ranks highest by a slight margin on providing a good view of the outside world and on having windows that are "about right" in size (items 27 and 34, appendix C, and items 28 and 26, appendix D). Despite the slightly higher level of satisfaction with the windows on the second floor, however, the majority of persons on that floor still considered the windows to be inadequate.

Facing page:

The fifth floor of the Norris Cotton Building features "systems furniture" with built-in task lighting.

6. DISCUSSION

A crucial question to be considered is, "How does user acceptance of the energy efficient design features in the Norris Cotton Building compare with acceptance of the more conventional design features found in other office buildings?" In other words, to what extent, if any, has the comfort of those who work in the Norris Cotton Building been sacrificed to achieve energy savings? In general, the thermal environment and the windows appear to be less satisfactory than in other open-plan office buildings, while the lighting and acoustical environment compare

rather well. Further comparisons reveal a number of similarities between the results of this study and those obtained from studies of more conventional buildings. For instance, many of the aspects which occupants particularly liked have largely to do with the way the building looks (e.g., appearance, newness, cleanness), while dislikes are more apt to concern the way it functions (e.g., temperature, ventilation, windows). This agrees with the results reported by Brookes (1972) and Elder et al. (1979), as does the finding that the desire for privacy is strong in open-plan offices (item 4 of both questionnaires).

An analysis of the response to the specific design features in the Norris Cotton Building also shows some areas of general agreement with the response obtained in other studies. For example, the finding that lighting was the most satisfactory design feature studied is consistent with the results of Wolgers (1973), Boyce (1974), and Elder et al. (1979). On all but the fourth floor most respondents were satisfied with the lighting, despite the variety of lighting systems installed in the building.

The fact that the fourth floor high pressure sodium lighting system installation was uniquely perceived as providing an insufficient amount of light to work by despite the fact that illumination levels on that floor were among the highest in the building is noteworthy for two reasons. First, it agrees with the finding of Aston and Bellchambers (1969) that people require more light in order to be satisfied if they do not like the way the light renders colors. Second, it underlines the importance of qualitative as well as quantitative factors in determining user satisfaction (e.g., the kind of light or noise in an office and how it is distributed).

It is possible that if the environment in which the high pressure sodium lighting was used had been more carefully controlled as Williams (1975) recommends (section 2.3.1), occupant response to the lighting might not have been so negative. In particular, the use of transition zones at fourth floor entries might have mitigated the negative response. Also, occupant complaints of glare might have been reduced if better contrast rendition had been provided in some locations on the fourth floor (see table 3). Furthermore, because of the particular nature of the work performed on the fourth floor (physical examinations which included tests requiring accurate color discriminations for diagnosis), the poor color rendition of the high pressure sodium lamps was possibly a more serious problem there than it would have been on floors where routine office work was performed.

Another interesting point about the lighting is that, as in other studies (Manning, 1965; Wells, 1965; Markus, 1967), those preferring natural light greatly outnumbered those preferring artificial light (item 20, first questionnaire and item 17 of the second). On both questionnaires, about 95 percent indicated a preference for at least some daylight in their offices. The vast majority, however, indicated a preference for a combination of daylight and artificial light, in agreement with the

study by Elder et al. (1979) of a building in which the amount of daylight was much higher than in the Norris Cotton Building. The magnitude of the difference in satisfaction between the second and sixth floors (figure 10) suggests the possibility that when the ratio of natural to artificial light is low, a relatively modest increase in the amount of daylight might substantially improve satisfaction. This possibility could not be tested under the conditions studied here, however, since the increase in daylight on the second floor was accompanied by an increase in both view and illumination level. Laboratory studies isolating the effects of daylight, view, and illumination level on user satisfaction are needed.

In general, the noise climate in the Norris Cotton Building appears to be no worse than in other buildings with predominantly open-plan offices. In the open-plan office space in the building, roughly equal numbers were satisfied and dissatisfied with the noise level (figure 11), as in the studies by Wolgers (1973) and Elder et al. (1979). More than 60 percent on both questionnaires said their offices never became too noisy to work in. By comparison, Boyce (1974) found that on a three-point scale (often, seldom, and never), about 50 percent reported that their work was "often" disturbed by noise, while less than 10 percent said that they were "never" disturbed by it.

The finding that occupants in the open-plan offices had experienced more work disruption due to noise than had occupants in the partitioned offices is typical of the results of other studies, but the fact that satisfaction with the noise level was statistically different according to office type on the first questionnaire but not on the second is not readily explained. It may reflect an adaptation to the noisiness of the open-plan offices over time, or it may be due to an actual decrease in the amount of noise, although no physical data were available to confirm that a decrease actually occurred. The finding that on the first questionnaire only eight percent were not especially bothered by particular noises (item 18) while on the second questionnaire 30 percent were not annoyed (item 16) also indicates an improvement in occupants' perceptions of the auditory environment.

The results of this study agree with the findings that conversational noise is the most disturbing type of noise in open-plan offices (Brookes, 1972; Nemecek and Grandjean, 1973; Elder et al., 1979) and that most noise disturbances are internally generated (Nemecek and Grandjean, 1973; Elder et al., 1979). Despite the downtown location of the Norris Cotton Building, only five percent of the respondents considered outside noise a problem. The sealed, double-glazed windows and limited amount of exterior glazing might have contributed to this finding.

There are very few data with which to compare the response to odor. Elder et al. (1979) measured satisfaction with odor on the same

five-point scale used in the present study with very similar results. Both studies found mainly "satisfied" and "indifferent" responses to odor, with relatively little dissatisfaction.

Although the response to odor on floors one through three showed a statistically significant difference from the response on floors four through seven on both questionnaires, these differences reflect shifts between the "satisfied" and "indifferent" categories of response. The percentage of respondents who were dissatisfied was approximately the same for both groups (figure 14). Thus the relatively slower rate of air exchange measured on floors four through seven did not seem to result in any serious odor problems on those floors.

Although survey studies of other office buildings have often uncovered problems with the heating, ventilating, and air conditioning systems (Wolgers, 1973; Boyce, 1974; Elder et al., 1979), with the exception of the latter study, the extent of negative opinion in the Norris Cotton Building appears to be atypical. It would appear that the main reason for the negative response is that temperatures are simply felt to be too cold, particularly during the heating season. Appendices F and G show that this complaint was about twice as common as any other about the temperature. At the time of the first questionnaire survey in March 1977, Federal guidelines were in effect specifying thermostat settings not to exceed 68°F (20°C). As the study by Gagge and Nevins (1976) shows, temperatures of 68°-70°F (20°-21°C) can be made acceptable to 80 percent of suitably clothed persons. However, their study indicates that for optimum satisfaction, there should be a direct rather than an inverse relationship between temperature and air movement (i.e., increased air movement should accompany higher rather than lower temperatures). In the Norris Cotton Building, physical measurements (Hunt, 1979) showed an average ventilation rate of about 40-50 cubic feet per minute (cfm) per person -- two or three times the 15-25 cfm per person recommended for offices by ASHRAE.* If the building could be operated at the ventilation levels recommended by ASHRAE, there might thus be greater acceptance of the temperatures in it. For the higher temperatures experienced during the summer months, it might be necessary to increase the ventilation rate, particularly on the fourth through the seventh floors, to maintain the level of acceptance. Since "comfortable temperature" is considered the most important office feature by the occupants of the building (item 8, first questionnaire and item 7 of the second), the potential for increasing overall satisfaction with the office environment by improving thermal comfort is great.

The very negative response to the windows contrasts with the results of Boyce (1974) and Elder et al. (1979), but is predictable in light of the scale model studies of preferred window size conducted by

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* American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Ne'eman and Hopkinson (1970), Keighley (1973b), and Ludlow (1976). These studies indicate that six percent glazing of the exterior wall -- the approximate percentage in most of the Norris Cotton Building -- is insufficient for the majority of people.

Although the second floor windows covered 12 percent of the exterior wall -- twice the amount found on the other floors -- only 17 percent of the persons on the second floor were satisfied with the window size on the first questionnaire, and 28 percent on the second questionnaire. One reason why opinion was not more positive on this floor may be the way in which the window area is distributed. As figure 3 shows, the additional window area on the second floor is concentrated near the ceiling; at eye level the windows are very narrow. Although this type of placement increases daylight penetration, studies have shown that view is a very important window benefit for people (Collins, 1975, pp. 53, 76), and that a view which provides a horizontal scan rather than a vertical one is preferable (Ne'eman and Hopkinson, 1970; Keighley, 1973a; Ludlow, 1976). The view quality on the second floor is further restricted by the six-foot overhang above the windows on that floor, which decreases both daylight penetration and sky view. While a view of the sky may not be the most important aspect of a view, Markus (1967) suggests that a good view must contain three elements -- foreground, middle ground, and sky. If people feel that the design of their windows provides them with a good view, they can apparently be satisfied by smaller windows than when their visual information about the outside world is limited.

Facing page:

The cubical shape and windowless north facade of the Norris Cotton Building help minimize surface heat loss.

7. SUMMARY AND CONCLUSIONS

User acceptance of the energy efficient design features of the Norris Cotton Building was studied by administering a questionnaire to employees shortly after occupancy of the building and again eight months later after both winter and summer conditions had been experienced.

In general, the most positive design feature was the lighting, but reaction to the high pressure sodium lighting system installation

was strongly negative. There was some indication that color rendition, glare, and amount of daylight may affect satisfaction.

Reaction to the thermal environment was extremely negative throughout the building. Ventilation levels in the building were considerably in excess of ASHRAE recommendations and may have exaggerated the effects of low temperatures during the winter months. Lower ventilation levels on the four upper floors were associated with more complaints of stuffiness, particularly during the summer.

Opinion on noise levels and disturbances was slightly more positive than negative overall, but about evenly divided in the open-plan offices. Response was very negative on the sixth floor, possibly due to the use of white noise generators. Voices were the most disturbing source of noise.

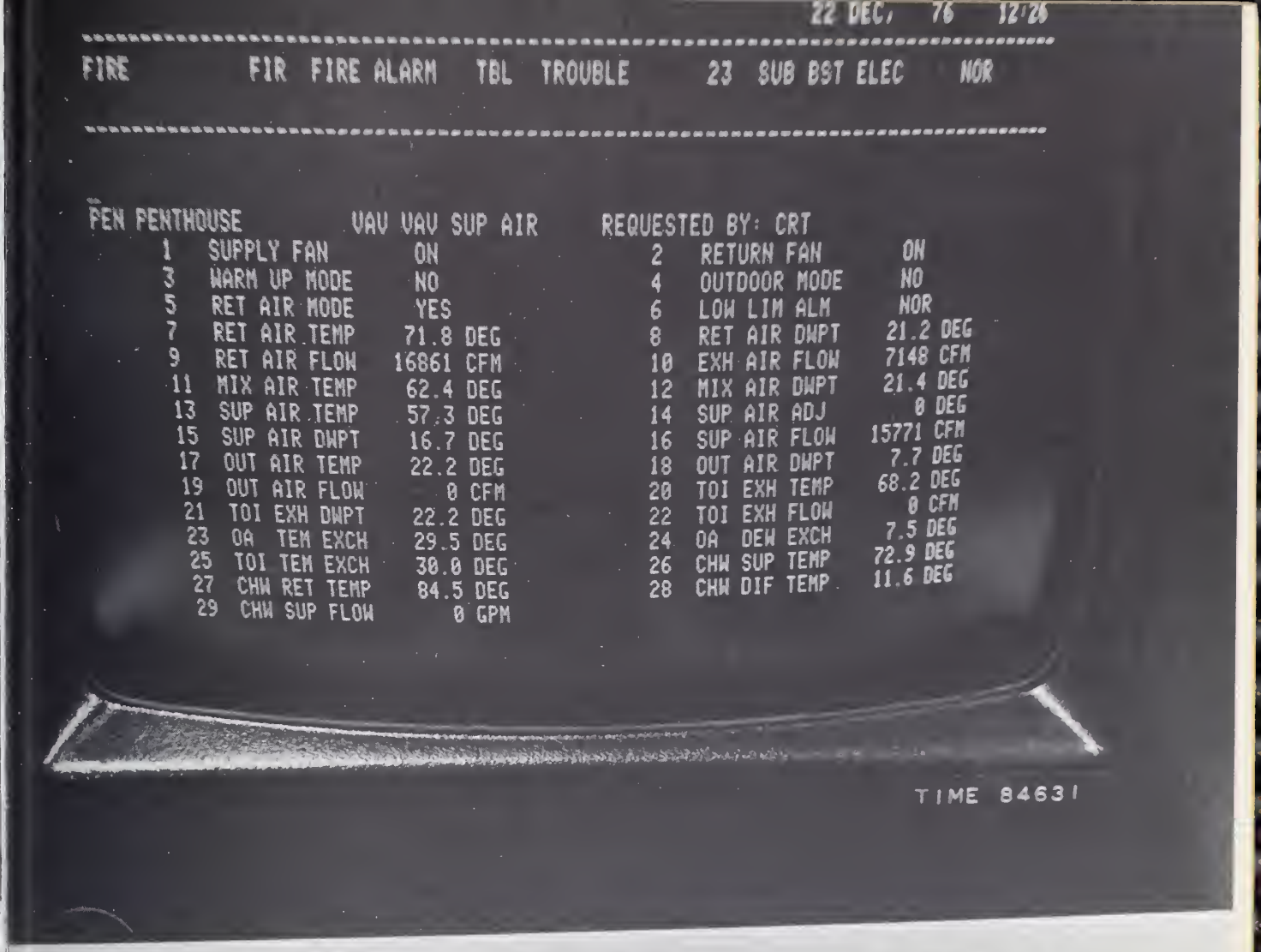
Most respondents were dissatisfied with the small windows in the building. The windows were also perceived to be too narrow to provide a sufficient view. The increased window area on the second floor did not substantially improve acceptance.

In summary, the Norris Cotton Building appears to compare favorably with other open-plan office buildings in the areas of lighting and acoustics, but unfavorably in terms of the windows and the thermal environment. Occupants rated the building much higher in appearance than the previous offices they had, slightly higher in terms of suitability for performance of their jobs, and slightly lower with respect to comfort.

Finally, it should be remembered that the Norris Cotton Building was created as a laboratory in which a variety of energy conservation measures could be tested. Because of its experimental nature, it was not expected that user acceptance would be high in all instances. The purpose of the building evaluation studies being carried out by the National Bureau of Standards is to determine the energy efficiency of the various design alternatives, and to learn what employee reaction to each of these alternatives will be. The knowledge gained from these studies will assist architects and engineers in designing buildings which will conserve energy and provide comfortable environments for their users.

Facing page:

A computerized monitoring and control system provides information on the performance of the systems in the Norris Cotton Building.



8. FUTURE RESEARCH NEEDS

One major shortcoming in today's design process is that buildings are seldom evaluated after they are built and occupied. Consequently, not enough is known about the extent to which buildings serve their intended users and function as envisioned by the designer. There is a need to identify, develop, and apply user information as an integral part of the design process.

The development of user information and the identification of linkages between user behavior and design decisions must become part of an overall design process model (including such factors as site selection and economic analysis; operations and building programming). To meet this general objective, the following activities should be pursued:

- Exploration of means to improve interaction between designers, users, and clients that will produce information needed to ensure a building design responsive to the needs of all building users.

- Further work to revise, test, and standardize measurement methods when collecting data on user needs and building performance requirements.

- A detailed study of the building design process to better identify linkages between design decisions and their ultimate influence on building users.

- Development of a feedback mechanism so information about a building's operation may be incorporated in the design of new buildings and the operation of existing ones.

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Appendix A

Cover Letter, Questionnaire #1, Percentage Summaries of Responses to Questionnaire #1

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

March 21, 1977

MEMORANDUM FOR: All Employees in the Norris Cotton Federal Building

From: Jacqueline Elder *je*
Research Psychologist
National Bureau of Standards

Subject: Norris Cotton Federal Building -- Building Environment Questionnaire

The Norris Cotton Federal Building has a number of energy conserving design features. In evaluating these features it is important to determine not only their engineering and economic performance but also to determine employee reaction to them. The attached questionnaire has been developed for this purpose.

We would appreciate it if you would complete this questionnaire at your earliest convenience. You will not be identified so please do not put your name on the questionnaire. You should rate the characteristics of the office in terms of your own feelings. Please do not confer with anyone as we would like to know how you feel.

Thank you very much for taking the time to answer these questions about your office. If you have any questions, please do not hesitate to call Jackie Elder or Belinda Collins at 301-921-2177.

PERCENTAGE SUMMARIES OF RESPONSES
NORRIS COTTON FEDERAL BUILDING -
BUILDING ENVIRONMENT QUESTIONNAIRE #1

Number of Responses (N)

1. Is there anything you particularly like about the Norris Cotton Federal Building?

N		
	/_/	Yes 66%
265	/_/	No 34

If yes, what do you like? Location (21), Appearance (14), Newness (9), Cleanness (7), Atmosphere (6), Design (4)

2. Is there anything you particularly dislike about the Norris Cotton Federal Building?

	/_/	Yes 83
273	/_/	No 17

If yes, what do you dislike? Temperature (32), Elevators (26), Parking (18), Windows (18), Ventilation (17), Lack of Cafeteria (13), Heavy Front Doors (11), Lighting (11).

3. How does your office or work area in this building compare with the last office you had?

	a. Appearance			b. Comfort			c. Suitability for Performance of Job		
	/_/	Better	80	/_/	Better	35	/_/	Better	38
274	/_/	Same	11	271 /_/	Same	24	272 /_/	Same	31
	/_/	Worse	9	/_/	Worse	41	/_/	Worse	31

4. Would you like to change your present office in any way?

	/_/	Yes 71
272	/_/	No 29

If yes, how? Temperature (15), More privacy (14), Windows (13), Lighting (8), More space (8), Less noise (6)

5. Please read all the categories and then check the kind of office you are in.

N

/_/ A private office enclosed with full height walls. 14

/_/ An office, enclosed with full height walls, shared with one other person. 8

274

/_/ An open office (no dividers or furniture that blocks the view) shared with 2 or more other people. 30

/_/ An individual space enclosed (or mostly enclosed) by dividers, plants or file cabinets etc. in an otherwise open office. Have little or no view of other workers. 16

/_/ Have some dividers, plants, file cabinets that tend to break up an open office but do not enclose the work space. Can readily see other workers. 32

6. In your last office, how many people shared your room or work area?

/_/ Had an office alone 22

/_/ Less than 4 people 28

273

/_/ 5-10 people 33

/_/ 11-20 people 12

/_/ More than 20 people 6

7. How many people share your current room or work area?

/_/ Have an office alone 19

/_/ Less than 4 people 29

275

/_/ 5-10 people 29

/_/ 11-20 people 10

/_/ More than 20 people 13

8. Check the <u>three</u> physical features that are most important to you in making an office a pleasant place for you to work.

262

/_/ Comfortable temperature 81

/_/ Good light 68

/_/ Freedom from noise 34

/_/ Good ventilation 32

/_/ A window 23

/_/ Privacy 25

/_/ Plenty of space 16

/_/ General environment (colors, carpet, decoration) 20

/_/ Other (please specify) 2

9. About how satisfied are you with the following aspects of your office?

N		Very satisfied	Somewhat satisfied	Indifferent	Somewhat dissatisfied	Very dissatisfied
277	a. Lighting	/_/ 42	/_/ 20	/_/ 6	/_/ 17	/_/ 15
277	b. Noise level	/_/ 23	/_/ 27	/_/ 8	/_/ 25	/_/ 17
273	c. Odor of office	/_/ 38	/_/ 16	/_/ 35	/_/ 6	/_/ 4
275	d. Ventilation	/_/ 16	/_/ 25	/_/ 15	/_/ 24	/_/ 19
276	e. Temperature	/_/ 4	/_/ 15	/_/ 5	/_/ 28	/_/ 47
266	f. Window size	/_/ 4	/_/ 8	/_/ 23	/_/ 20	/_/ 44

10. Does it ever get cold enough to make you feel uncomfortable?

279
- /_/ Often 59
- /_/ Sometimes 24
- /_/ Only occasionally 11
- /_/ Never 6
- /_/ Don't know/no opinion

11. Does it ever get warm enough to make you feel uncomfortable?

229
- /_/ Often 17
- /_/ Sometimes 23
- /_/ Only occasionally 24
- /_/ Never 36
- /_/ Don't know/no opinion

12. Does it ever seem uncomfortably stuffy?

259
- /_/ Often 22
- /_/ Sometimes 29
- /_/ Only occasionally 20
- /_/ Never 29
- /_/ Don't know/no opinion

13. Does it ever seem uncomfortably humid?

N

/_/ Often 6

/_/ Sometimes 11

221 /_/ Only occasionally 14

/_/ Never 70

/_/ Don't know/no opinion

14. Do you ever notice unpleasant odors in your office or work area?

/_/ Often 7

/_/ Sometimes 9

261

/_/ Only occasionally 20

/_/ Never 64

/_/ Don't know/no opinion

15. What do you do if your office gets too cold? Dress warmly (75), Complain (13), Nothing (12), Leave work station (8), No comments (4)

279 too warm? No comments (46), Nothing (27), Remove warm clothing (20), Complain (5), Leave work station (2)

too stuffy? No comments (50), Nothing (29), Leave work station (9), Complain (6), Remove warm clothing (3)

too humid? No comments (69), Nothing (21), Complain (4), Leave work station (2), Remove warm clothing (2)

16. How does the noise level in this office compare with that of other offices in which you have worked?

/_/ More noise in present office 39

274 /_/ About the same 34

/_/ Less noise in present office 26

17. Does your office ever become so noisy that you find it difficult to work?

/_/ Yes 38

269 /_/ No 62

/_/ Don't know/no opinion

18. What noises do you notice most as you work? (Check as many as apply.)

N
276

/_/ None 8

/_/ Office machines 39

/_/ Outside noise 5

/_/ Telephones 40

/_/ Voices 59

/_/ People walking around 17

/_/ Other (please specify) 32 (HVAC (18)*, White noise (12))

19. Do you prefer working by natural light, artificial light or a combination of natural and artificial?

247

/_/ Prefer natural 22

/_/ Prefer artificial 4

/_/ Prefer combination 74

/_/ Don't know/no opinion

20. In general, do you think the light level, artificial and natural combined, is about right for your work?

256

/_/ About right 68

/_/ Too little light 28

/_/ Too much light 4

/_/ Don't know/no opinion

21. With the artificial light, does the color of objects in the room seem:

226

/_/ Natural 75

/_/ Unnatural 25

/_/ Don't know/no opinion

22. With the artificial light, does the complexion of office occupants seem:

232

/_/ Natural 75

/_/ Unnatural 25

/_/ Don't know/no opinion

*18% of 276

23. Does the artificial light ever cause enough glare to bother you?

N
270

/_/ Often 15

/_/ Sometimes 22

/_/ Only occasionally 16

/_/ Never 47

/_/ Don't know/no opinion

24. Do you have any other comments about the lighting?

279 No comments (60), Dislike it (7), Like it (6), Too little (6), Causes eyestrain (4), Need more daylight (4)

25. How important is it to you to have a window in your office or immediate work area?

272

/_/ Very important 40

/_/ Moderately important 42

/_/ Not important 18

/_/ Don't know/no opinion

26. Do you have a window or windows in your office or work area?

278

/_/ Yes 69

/_/ No 31

If yes, answer questions 24 through 35.

If no, skip to question 36.

27. Are you able to see as much of the outside world as you would like from your desk?

190

/_/ Yes 18

/_/ No 82

/_/ Don't know/no opinion

28. Which of the following best describe the view out of the window closest to you? (Check as many as apply.)

N

194

/_/	satisfying	12	/_/	open	5
/_/	limited	72	/_/	bright	4
/_/	simple	9	/_/	uncluttered	2
/_/	pleasant	11	/_/	frustrating	16
/_/	confined	35	/_/	complex	1
/_/	dim	10	/_/	boring	22
/_/	stimulating	1	/_/	unpleasant	16
/_/	cluttered	13	/_/	spacious	2

29. Do you ever work using only the light from the windows?

193

/_/ Often 1

/_/ Sometimes 2

/_/ Only occasionally 3

/_/ Never 94

/_/ Don't know/no opinion

30. How about the light from the windows, does it ever cause enough glare to bother you?

188

/_/ Often 3

/_/ Sometimes 6

/_/ Only occasionally 7

/_/ Never 84

/_/ Don't know/no opinion

31. Does your office ever become too hot because of the sunshine coming in the windows?

162

/_/ Often 0

/_/ Sometimes 4

/_/ Only occasionally 2

/_/ Never 94

/_/ Don't know/no opinion

32. Do you ever notice cold drafts near the windows?

N
178

/_/ Often 30

/_/ Sometimes 13

/_/ Only occasionally 11

/_/ Never 46

/_/ Don't know/no opinion

33. Do you think the noise level near the window is noticeably greater than in other areas of the room?

153

/_/ Often 0

/_/ Sometimes 1

/_/ Only occasionally 10

/_/ Never 89

/_/ Don't know/no opinion

34. How about the size of your window, is it:

174

/_/ About right 13

/_/ Too big 0

/_/ Too small 87

/_/ Don't know/no opinion

35. Do you think your window is:

139

/_/ About the right proportions 22

/_/ Too high for its width 78

/_/ Too wide for its height 0

/_/ Don't know/no opinion

36. Listed below are some of the advantages of windows. Check the three that are most important to you.

N

/_/ Let you tell time of day 7

/_/ Let sunshine in 59

/_/ Let you know what the weather is 59

/_/ Let in warmth 13

/_/ Let you see what's going on outside 17

238

/_/ Provide a way for fresh air to enter 45

/_/ Give a change of view to break monotony 57

/_/ Provide light for plants 7

/_/ Make a room seem more spacious 30

/_/ Other (please specify) 6

37. Listed below are some of the disadvantages of windows. Check the three that you feel are the biggest disadvantages.

/_/ Let in too much heat in summer 48

/_/ Let in too much cold air in winter 66

/_/ Cause glare 45

/_/ Reduce privacy 12

128 /_/ Let in outside noises 50

/_/ Limit ways furniture can be arranged 26

/_/ Give too much sunlight 16

/_/ Present a hazard (might get broken) 19

/_/ Present a hazard (person might fall) 10

/_/ Other (please specify) 8

38. Do you have any other comments about the windows? No comments (61), Too small (12), Want them to open (10), Like the idea of having windows (8), Too few (5)

279

39. Which of the following activities are a normal part of your job? (Check each one you usually do as a part of your job.)

N
278

/_/ Reading 91

/_/ Writing (including shorthand) 83

/_/ Typing 45

/_/ Using other keyboard machines (calculator, key punch, computer terminal, etc.) 37

/_/ Filing 41

/_/ Working with numbers 66

/_/ Making drawings 3

/_/ Laboratory work 1

/_/ Using the telephone 83

/_/ Interviewing or holding small meetings 47

/_/ Supervising the work of others 24

/_/ Other (please specify) 6 _____

40. In general, how much time do you spend in your office or immediate work area?

/_/ All the time (7-8 hours a day) 67

278 /_/ Most of the time (4-6 hours a day) 26

/_/ Very little (less than 4 hours a day) 3

/_/ Other (please specify) 4 _____

41. Do you have any other comments you would like to make about the Norris Cotton Federal Building? No comments (50), Poor parking (10),

279 Uncomfortable temperature (8), Need cafeteria (8), Elevators malfunction (8),

Like building (4), Front doors too heavy (4)

_____ Please go on to the next page

The following information is needed for data analysis only. It will not be used to identify any individual respondent.

42. How long have you worked in the Norris Cotton Federal Building?

_____

43. Which floor is your office on?

N
279 Floor number _____ 1(14), 2(17), 3(14), 4(11), 5(18), 6(16), 7(9)

44. Where was your last office?

_____
Number Street

_____
City State

45. Sex

267 /_/ Male 58

/_/ Female 42

46. Age

/_/ 17-25 16

/_/ 26-35 35

268

/_/ 36-50 25

/_/ Over 50 24

47. In general terms, what type of job do you have? (For example, clerk typist, supervisor, physician, etc.)

_____

_____

_____

Thank You Very Much

Appendix B

Cover Letter, Questionnaire #2, Percentage Summaries of Responses to Questionnaire #2

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

November 1977

MEMORANDUM FOR: All Employees in the Norris Cotton Federal Building

From: Jacqueline Elder
Research Psychologist
National Bureau of Standards

Subject: Norris Cotton Federal Building -- Building Environment Questionnaire #2

Last March I sent a questionnaire to you asking you to evaluate some of the design features of the Norris Cotton Building and to indicate the effect of these features on your working environment. Now that you have occupied the building for about a year and have experienced both winter and summer weather conditions, I would like to repeat the questionnaire.

I would appreciate it if you would complete the attached questionnaire at your earliest convenience. You will not be identified so please do not put your name on the questionnaire. You should rate the characteristics of the office in terms of your own feelings. Please do not confer with anyone as I would like to know how you feel.

Thank you very much for taking the time to answer these questions about your office. If you have any questions, please do not hesitate to call Jackie Elder at 301-921-2177.

PERCENTAGE SUMMARIES OF RESPONSES
NORRIS COTTON FEDERAL BUILDING -
BUILDING ENVIRONMENT QUESTIONNAIRE #2

Number of Responses (N)

1. Is there anything you particularly like about the Norris Cotton Federal Building?

N

213

/_/ Yes 61 %

/_/ No 39

If yes, what do you like? Location (28), Appearance (14), Newness (8), Lighting (7), Atmosphere (6), Cleanness (6)

2. Is there anything you particularly dislike about the Norris Cotton Federal Building?

218

/_/ Yes 79

/_/ No 21

If yes, what do you dislike? Temperature (49), Elevators (18), Parking (17), Ventilation (14), Windows (12), Lighting (11), Lack of cafeteria (10), Heavy front doors (7)

3. About how satisfied are you with the following aspects of the building?

		Very satisfied	Somewhat satisfied	Indifferent	Somewhat dissatisfied	Very dissatisfied
220	a. Parking	/_/ 24	/_/ 19	/_/ 8	/_/ 18	/_/ 31
219	b. Elevators	/_/ 9	/_/ 19	/_/ 13	/_/ 32	/_/ 27
218	c. Eating Facilities	/_/ 4	/_/ 12	/_/ 15	/_/ 19	/_/ 50
221	d. Exterior Appearance	/_/ 47	/_/ 19	/_/ 26	/_/ 4	/_/ 4

Please comment No comments (51), Poor parking (24, including lack of parking space (16) and paying for parking (8)), Inadequate eating facilities--mainly too small (24), Elevators malfunction (19)

4. Would you like to change your present office in any way?

216

/_/ Yes 65

/_/ No 35

If yes, how? Temperature (20), More privacy (14), Windows (13), Lighting (10), More space (8), Less noise (8), Ventilation (8)

5. Please read all the categories and then check the kind of office you are in.

N
218

15 /_/ A private office enclosed with full height walls.

6 /_/ An office, enclosed with full height walls, shared with one other person.

27 /_/ An open office (no dividers or furniture that blocks the view) shared with 2 or more other people.

20 /_/ An individual space enclosed (or mostly enclosed) by dividers, plants or file cabinets etc. in an otherwise open office. Have little or no view of other workers.

32 /_/ Have some dividers, plants, file cabinets that tend to break up an open office but do not enclose the work space. Can readily see other workers.

6. How many people share your current room or work area?

21 /_/ Have an office alone

27 /_/ Less than 5 people

219

26 /_/ 5-10 people

11 /_/ 11-20 people

13 /_/ More than 20 people

7. Check the <u>three</u> physical features that are most important to you in making an office a pleasant place for you to work.

212

/_/ Comfortable temperature 80

/_/ Good light 70

/_/ Freedom from noise 33

/_/ Good ventilation 42

/_/ A window 27

/_/ Privacy 20

/_/ Plenty of space 13

/_/ General environment (colors, carpet, decoration) 14

/_/ Other (please specify) 1

8. About how satisfied are you with the following aspects of your office?

N			Very satisfied	Somewhat satisfied	Indifferent	Somewhat dissatisfied	Very dissatisfied
219	a.	Lighting	/_/ 41	/_/ 32	/_/ 1	/_/ 13	/_/ 13
217	b.	Noise level	/_/ 19	/_/ 34	/_/ 12	/_/ 20	/_/ 15
216	c.	Odor of office	/_/ 31	/_/ 22	/_/ 32	/_/ 9	/_/ 6
216	d.	Ventilation	/_/ 12	/_/ 22	/_/ 12	/_/ 27	/_/ 26
215	e.	Temperature	/_/ 2	/_/ 12	/_/ 3	/_/ 32	/_/ 51
204	f.	Window size	/_/ 6	/_/ 11	/_/ 20	/_/ 24	/_/ 40

217 9. Does it ever get cold enough to make you feel uncomfortable?

/_/ Often 66

/_/ Sometimes 21

/_/ Only occasionally 11

/_/ Never 2

/_/ Don't know/no opinion

218 10. Does it ever get warm enough to make you feel uncomfortable?

/_/ Often 23

/_/ Sometimes 25

/_/ Only occasionally 27

/_/ Never 25

/_/ Don't know/no opinion

11. Does it ever seem uncomfortably stuffy?

212

/_/ Often 32

/_/ Sometimes 29

/_/ Only occasionally 25

/_/ Never 15

/_/ Don't know/no opinion

12. Does it ever seem uncomfortably humid?

N		
192	7	/_/ Often
	15	/_/ Sometimes
	24	/_/ Only occasionally
	54	/_/ Never
		/_/ Don't know/no opinion

13. Does it ever seem uncomfortably dry?

	22	/_/ Often
182	29	/_/ Sometimes
	22	/_/ Only occasionally
	27	/_/ Never
		/_/ Don't know/no opinion

14. Do you ever notice unpleasant odors in your office or work area?

	8	/_/ Often
203	18	/_/ Sometimes
	22	/_/ Only occasionally
	52	/_/ Never
		/_/ Don't know/no opinion

15. Does your office ever become so noisy that you find it difficult to work?

	39	/_/ Yes
207	61	/_/ No
		/_/ Don't know/no opinion

16. What noises bother you most as you work? (Check as many as apply.)

N
220

/_/ None 30

/_/ Office machines 20

/_/ Outside noise 5

/_/ Telephones 23

/_/ Voices 44

/_/ People walking around 13

/_/ Mechanical noise 20

/_/ Other (please specify) 13 (HVAC (7), White noise (4))

17. Do you prefer working by natural light, artificial light or a combination of natural and artificial?

19 /_/ Prefer natural

197 5 /_/ Prefer artificial

76 /_/ Prefer combination

/_/ Don't know/no opinion

18. In general, do you think the light level, artificial and natural combined, is about right for your work?

66 /_/ About right

204

30 /_/ Too little light

4 /_/ Too much light

/_/ Don't know/no opinion

19. With the artificial light, does the color of objects in the room seem:

72 /_/ Natural

188 28 /_/ Unnatural

/_/ Don't know/no opinion

20. With the artificial light, does the complexion of office occupants seem:

76 /_/ Natural

186

24 /_/ Unnatural

/_/ Don't know/no opinion

21. Does the artificial light ever cause enough glare to bother you?

N
212

17 /_/ Often

23 /_/ Sometimes

15 /_/ Only occasionally

45 /_/ Never

/_/ Don't know/no opinion

22. Are you able to turn off the overhead or built-in lights near your desk?

34 /_/ Yes

218

66 /_/ No

If yes, do you ever do so?

8 /_/ Often

71

4 /_/ Sometimes

8 /_/ Only occasionally

79 /_/ Never

/_/ Don't know/no opinion

23. Do you have any other comments about the lighting?

221 No comments (68), Dislike it (9), Like it (7), Too little (6), Too much glare (5), Too uneven (4)

24. How important is it to you to have a window in your office or immediate work area?

45 /_/ Very important

37 /_/ Moderately important

19 /_/ Not important

216

/_/ Don't know/no opinion

Why? No comments (57), Lessens caged feelings (13), See weather (13), Daylighting (9), View (9), Break monotony (5), Fresh air (5)

25. Do you have a window or windows in your office or work area?

N. 220

/_/ Yes 75

/_/ No 25

If yes, answer all questions.

If no, skip to question 31.

26. How about the size of your window, is it?

157

/_/ About right 19

/_/ Too big 0

/_/ Too small 81

/_/ Don't know/no opinion

27. Place a check mark on the line closest to the adjective that best describes your window. (A check on the middle line indicates no opinion.)

126	a) large	2	2	4	17	75	small
151	b) narrow	88	7	3	0	1	wide
127	c) satisfactory	12	7	13	23	46	unsatisfactory
118	d) irregular	40	9	27	9	14	regular
124	e) well proportioned	9	6	22	15	48	poorly proportioned

28. Are you able to see as much of the outside world as you would like from your desk?

158

/_/ Yes 15

/_/ No 85

/_/ Don't know/no opinion

29. Place a check mark on the line closest to the adjective that best describes the view from the window nearest to you. (A check on the middle line indicates no opinion.)

N							
126	a)	pleasant	25	17	33	11	14	unpleasant
123	b)	limited	63	19	8	6	4	open
120	c)	satisfying	11	14	32	20	23	frustrating
115	d)	complete	4	3	24	28	41	incomplete
117	e)	dim	31	11	32	19	8	bright
110	f)	divided	27	18	33	8	14	whole

30. Are you ever annoyed by the following aspects of the window or windows in your work area?

		Often	Sometimes	Only Occasionally	Never	Don't know/no opinion
143	a) Glare	/_/ 1	/_/ 10	/_/ 12	/_/ 78	/_/
144	b) Noise	/_/ 2	/_/ 1	/_/ 3	/_/ 94	/_/
141	c) Sunshine	/_/ 2	/_/ 7	/_/ 20	/_/ 71	/_/
135	d) Overheating in summer	/_/ 4	/_/ 5	/_/ 13	/_/ 78	/_/
138	e) Cold drafts in winter	/_/ 25	/_/ 13	/_/ 14	/_/ 48	/_/
139	f) Inability to open	/_/ 58	/_/ 9	/_/ 5	/_/ 28	/_/
147	g) Inability to change venetian blind setting	/_/ 43	/_/ 13	/_/ 12	/_/ 32	/_/

221 31. Do you have any other comments about the windows? No comments (71), Too small (10), Dislike them (6), Blinds malfunction (5), Too few (5), Can't open (4), Like them (3)

32. Which of the following activities are a normal part of your job? (Check each one you usually do as a part of your job.)

N

/_/ Reading 92

/_/ Writing (including shorthand) 83

/_/ Typing 48

220 /_/ Using other keyboard machines (calculator, key punch, computer terminal, etc.) 40

/_/ Filing 44

/_/ Working with numbers 74

/_/ Making drawings 5

/_/ Laboratory work 1

/_/ Using the telephone 87

/_/ Interviewing or holding small meetings 55

/_/ Supervising the work of others 27

/_/ Other (please specify) 3 _____

33. In general, how much time do you spend in your office or immediate work area?

221

67 /_/ All the time (7-8 hours a day)

26 /_/ Most of the time (4-6 hours a day)

4 /_/ Very little (less than 4 hours a day)

2 /_/ Other (please specify) _____

34. Do you have any other comments you would like to make about the Norris Cotton Federal Building? No comments (65), Uncomfortable temperature (12),

221

Poor ventilation (6), Dislike building (5), GSA unresponsive (4), Like building (3)

_____

Please go on to the next page

The following information is needed for data analysis only. It will not be used to identify any individual respondent.

N

35. How long have you worked in the Norris Cotton Federal Building?

218 1 year or longer (88), 6-12 mos. (7), 2-5 mos. (3), 1 mo. or less (2)

36. Which floor is your office on?

221 Floor number _____ 1(13), 2(21), 3(15), 4(10), 5(19), 6(19), 7(1)

37. Sex

220

57 /_/ Male

43 /_/ Female

38. Age

14 /_/ 17-25

38 /_/ 26-35

217

24 /_/ 36-50

24 /_/ Over 50

39. In general terms, what type of job do you have? (For example, clerk typist, supervisor, physician, etc.)

_____

_____

_____

Thank You Very Much

Appendix C

Floor-by-Floor Analysis of First Questionnaire Results

Question	Response	Floor 1	2	3	4	5	6	7
1	Yes	27	35	27	23	37	18	9
	No	10	11	11	6	12	26	13
2	Yes	28	41	38	26	39	35	20
	No	10	6	2	4	11	9	4
3a	Better	34	42	26	30	51	23	13
	Same	2	2	7	1	0	11	8
	Worse	3	3	4	0	0	10	4
3b	Better	24	14	6	11	30	3	6
	Same	5	13	7	7	10	17	6
	Worse	9	20	24	11	11	25	12
3c	Better	23	17	8	14	25	5	11
	Same	8	16	16	7	10	17	10
	Worse	7	13	12	10	16	23	4
4	Yes	20	31	27	22	37	37	19
	No	18	16	11	8	13	7	6
5	a	7	2	7	13	4	1	5
	b	1	0	3	9	1	2	5
	c	18	22	11	4	10	12	5
	d	8	3	2	1	15	9	7
	e	4	20	17	2	20	20	4
6	Alone	6	4	5	6	24	9	5
	Less than 4	8	15	8	15	10	4	16
	5-10	8	19	19	8	12	20	3
	11-20	8	5	3	0	4	12	0
	More than 20	9	4	2	1	0	0	1

Appendix C (continued)

Question	Response	Floor 1	2	3	4	5	6	7
7	Alone	4	2	8	12	16	6	5
	Less than 4	6	8	6	15	18	9	17
	5-10	9	13	21	2	13	18	3
	11-20	9	2	5	1	0	9	1
	More than 20	11	22	0	0	1	3	0
8	Comfortable temperature	31	39	34	22	30	34	21
	Good light	25	31	31	25	26	26	13
	Freedom from noise	12	16	9	9	21	17	5
	Good ventilation	14	12	9	16	5	19	10
	A window	5	12	12	5	5	11	10
	Privacy	5	8	5	8	24	11	5
	Plenty of space	10	6	7	4	8	3	3
	General environment	12	10	7	4	9	4	6
	Other	0	1	0	0	1	1	2
9a	Very satisfied	26	30	14	0	22	15	10
	Somewhat satisfied	6	12	8	1	12	10	6
	Indifferent	3	3	4	1	1	4	1
	Somewhat dissatisfied	4	2	7	7	10	10	6
	Very dissatisfied	0	0	7	21	5	6	3
9b	Very satisfied	13	13	16	14	3	1	3
	Somewhat satisfied	16	17	10	8	12	5	7
	Indifferent	4	3	4	3	4	2	3
	Somewhat dissatisfied	4	12	9	1	19	16	9
	Very dissatisfied	2	2	1	3	13	21	4
9c	Very satisfied	16	24	25	12	17	6	5
	Somewhat satisfied	8	9	3	7	10	4	3
	Indifferent	10	10	7	5	22	26	16
	Somewhat dissatisfied	4	2	4	3	0	3	1
	Very dissatisfied	0	0	0	3	2	5	1

Appendix C (continued)

Question	Response	Floor 1	2	3	4	5	6	7
9d	Very satisfied	10	8	7	6	9	3	0
	Somewhat satisfied	12	14	6	7	16	10	5
	Indifferent	5	10	7	5	9	4	2
	Somewhat dissatisfied	9	7	10	7	11	15	8
	Very dissatisfied	3	7	9	4	6	13	11
9e	Very satisfied	4	0	0	4	2	2	0
	Somewhat satisfied	9	5	1	3	11	9	3
	Indifferent	0	4	0	3	3	2	2
	Somewhat dissatisfied	13	12	9	6	16	14	8
	Very dissatisfied	13	26	30	13	18	18	13
9f	Very satisfied	3	3	0	2	2	1	0
	Somewhat satisfied	5	5	4	1	2	2	2
	Indifferent	10	15	7	7	16	6	1
	Somewhat dissatisfied	10	11	7	4	12	5	5
	Very dissatisfied	11	13	20	12	15	30	17
10	Often	20	35	36	16	30	15	14
	Sometimes	14	7	3	4	14	16	9
	Only occasionally	4	5	0	7	3	9	2
	Never	1	0	1	4	4	5	1
11	Often	3	13	1	1	6	10	5
	Sometimes	14	6	6	3	9	11	3
	Only occasionally	2	10	4	6	14	12	7
	Never	14	11	17	12	14	8	7
12	Often	5	10	5	5	6	18	9
	Sometimes	16	10	7	9	13	14	6
	Only occasionally	6	9	5	8	13	5	6
	Never	11	16	15	6	14	7	5

Appendix C (continued)

Question	Response	Floor 1	2	3	4	5	6	7
13	Often	2	0	1	2	1	6	1
	Sometimes	6	5	2	3	1	4	3
	Only occasionally	8	6	3	3	3	5	2
	Never	16	28	21	17	39	21	12
14	Often	2	3	1	3	2	5	2
	Sometimes	4	4	1	6	4	3	2
	Only occasionally	5	6	3	11	10	14	4
	Never	23	32	32	11	33	19	16
16	More	6	17	8	5	20	40	12
	Same	17	23	13	9	18	5	9
	Less	15	7	16	17	12	0	5
17	Yes	7	14	6	7	34	26	9
	No	31	30	33	22	16	17	17
18	None	5	7	2	7	1	0	1
	Office machines	7	25	26	6	29	7	7
	Outside noise	3	4	2	3	2	0	0
	Telephones	16	21	17	8	30	12	8
	Voices	20	32	23	10	46	21	11
	People walking around	5	4	8	7	14	4	5
	Other	5	5	6	10	9	37	16
19	Prefer natural	5	3	8	10	14	7	8
	Prefer artificial	3	2	1	0	1	2	1
	Prefer combination	24	34	26	21	30	31	16
20	About right	29	35	24	6	35	26	20
	Too little light	3	5	13	19	14	15	2
	Too much light	2	2	2	1	0	1	2

Appendix C (continued)

Question	Response	Floor 1	2	3	4	5	6	7
21	Natural	29	34	25	0	42	27	12
	Unnatural	4	5	6	30	3	3	6
22	Natural	29	36	25	2	42	28	13
	Unnatural	5	5	6	27	5	4	5
23	Often	1	2	6	17	7	6	2
	Sometimes	10	6	5	5	14	11	8
	Only occasionally	7	6	3	2	8	8	8
	Never	19	31	24	7	21	19	7
25	Very important	12	21	26	6	9	18	17
	Moderately important	17	22	7	13	28	22	5
	Not important	10	3	5	11	13	3	4
26	Yes	32	42	31	17	25	30	16
	No	7	5	8	14	26	15	10
27	Yes	2	11	6	5	6	4	1
	No	29	30	26	11	19	25	15
29	Often	0	0	0	0	0	0	1
	Sometimes	0	1	0	1	0	2	0
	Only occasionally	1	2	3	0	0	0	0
	Never	31	38	30	16	25	27	15
30	Often	0	6	0	0	0	0	0
	Sometimes	2	6	1	0	1	2	0
	Only occasionally	1	2	4	1	2	3	0
	Never	29	26	27	15	22	22	16
31	Often	0	0	0	0	0	0	0
	Sometimes	1	2	0	0	0	2	1
	Only occasionally	1	1	0	0	1	0	1
	Never	27	34	24	16	21	16	14

Appendix C (continued)

Question	Response	Floor 1	2	3	4	5	6	7
32	Often	9	11	19	7	4	2	1
	Sometimes	4	6	5	3	2	4	0
	Only occasionally	6	2	1	3	1	3	3
	Never	11	16	5	4	18	17	11
33	Often	0	0	0	0	0	0	0
	Sometimes	0	1	0	0	0	0	0
	Only occasionally	4	5	0	3	2	0	2
	Never	22	26	23	12	20	23	10
34	About right	5	8	1	1	3	2	2
	Too big	0	0	0	0	0	0	0
	Too small	24	29	28	13	20	26	12
35	About right	8	8	4	1	6	3	1
	Too high	20	18	17	12	12	19	10
	Too wide	0	0	0	0	0	0	0
40	All the time	31	39	23	20	30	26	18
	Most of the time	6	3	14	9	20	11	8
	Very little	2	3	1	1	0	2	0
	Other	0	2	2	1	0	6	0
45	Male	20	33	11	25	31	23	12
	Female	19	14	26	6	19	17	11
46	17-25	5	9	13	3	5	4	4
	26-35	15	20	12	12	11	12	13
	36-50	13	6	3	10	15	14	5
	Over 50	6	12	9	6	18	11	2

Appendix D

Floor-by-Floor Analysis of Second Questionnaire Results

Question	Response	Floor 1	2	3	4	5	6	7
1	Yes	16	32	20	14	27	19	2
	No	12	15	13	8	14	21	0
2	Yes	14	38	29	20	32	37	2
	No	15	9	5	3	9	5	0
3a	Very satisfied	13	5	10	8	9	6	1
	Somewhat satisfied	7	8	8	2	4	11	1
	Indifferent	0	4	4	3	2	5	0
	Somewhat dissatisfied	6	10	5	4	6	9	0
	Very dissatisfied	3	20	7	6	21	11	1
3b	Very satisfied	5	5	3	4	2	1	0
	Somewhat satisfied	7	7	10	8	5	3	2
	Indifferent	9	7	2	1	5	5	0
	Somewhat dissatisfied	4	17	9	9	15	15	0
	Very dissatisfied	3	11	9	1	16	18	1
3c	Very satisfied	0	0	3	3	1	1	0
	Somewhat satisfied	7	2	10	4	2	1	0
	Indifferent	3	6	3	6	4	10	1
	Somewhat dissatisfied	9	3	6	5	9	8	1
	Very dissatisfied	9	36	11	5	26	22	1
3d	Very satisfied	15	23	20	15	18	12	0
	Somewhat satisfied	6	12	4	3	10	5	1
	Indifferent	7	5	7	4	11	20	2
	Somewhat dissatisfied	0	2	2	0	2	2	0
	Very dissatisfied	0	3	1	1	1	3	0

Appendix D (continued)

Question	Response	Floor 1	2	3	4	5	6	7
4	Yes	13	34	19	15	25	32	3
	No	16	11	15	8	17	8	0
5	a	5	3	7	12	3	2	1
	b	2	2	2	7	1	0	0
	c	18	16	9	1	10	5	0
	d	3	5	5	0	18	11	1
	e	1	21	11	1	11	24	0
6	Alone	4	3	9	11	11	8	1
	Less than 5	5	11	3	11	20	8	2
	5-10	3	14	22	0	8	11	0
	11-20	9	3	0	0	3	10	0
	More than 20	8	16	0	0	0	5	0
7	Comfortable temperature	28	43	29	17	26	25	1
	Good light	22	26	26	16	23	35	1
	Freedom from noise	11	19	5	5	12	18	0
	Good ventilation	10	21	10	10	19	18	1
	A window	4	10	13	7	9	12	2
	Privacy	1	8	3	4	14	11	1
	Plenty of space	2	4	6	3	9	3	0
	General environment	8	5	7	1	8	1	0
	Other	1	2	0	0	0	0	0
8a	Very satisfied	22	29	12	1	14	9	2
	Somewhat satisfied	6	13	14	2	18	16	0
	Indifferent	0	0	2	0	1	0	0
	Somewhat dissatisfied	1	3	4	5	5	10	1
	Very dissatisfied	0	1	2	14	5	7	0
8b	Very satisfied	11	6	10	5	7	2	1
	Somewhat satisfied	13	14	13	10	16	6	1
	Indifferent	2	6	5	4	2	5	1
	Somewhat dissatisfied	1	13	4	3	12	11	0
	Very dissatisfied	2	5	2	0	6	18	0

Appendix D (continued)

Question	Response	Floor 1	2	3	4	5	6	7
8c	Very satisfied	10	12	18	7	13	6	0
	Somewhat satisfied	5	16	7	5	8	7	0
	Indifferent	7	11	7	6	17	19	3
	Somewhat dissatisfied	5	2	2	2	2	6	0
	Very dissatisfied	2	5	0	2	1	3	0
8d	Very satisfied	6	4	6	4	2	5	0
	Somewhat satisfied	9	13	5	3	9	6	2
	Indifferent	1	6	5	3	5	7	0
	Somewhat dissatisfied	5	7	13	4	16	13	1
	Very dissatisfied	8	15	5	7	10	11	0
8e	Very satisfied	0	0	2	1	2	0	0
	Somewhat satisfied	6	4	2	1	6	4	2
	Indifferent	0	1	0	1	0	5	0
	Somewhat dissatisfied	15	11	7	4	15	15	1
	Very dissatisfied	8	30	23	14	18	17	0
8f	Very satisfied	2	5	0	3	2	0	0
	Somewhat satisfied	4	7	2	2	4	3	0
	Indifferent	5	10	8	2	11	5	0
	Somewhat dissatisfied	10	6	12	2	10	8	0
	Very dissatisfied	8	15	12	7	12	24	3
9	Often	17	34	27	18	22	24	1
	Sometimes	11	11	4	1	11	8	0
	Only occasionally	1	1	3	1	7	8	2
	Never	0	0	0	1	2	2	0
10	Often	5	8	2	10	15	9	1
	Sometimes	10	6	5	6	12	15	1
	Only occasionally	8	11	12	1	12	14	1
	Never	6	22	15	4	3	4	0

Appendix D (continued)

Question	Response	Floor 1	2	3	4	5	6	7
11	Often	11	13	4	9	19	11	1
	Sometimes	10	14	10	4	10	13	0
	Only occasionally	4	8	8	6	13	11	2
	Never	4	11	8	2	1	5	0
12	Often	1	3	0	3	5	1	0
	Sometimes	8	2	3	6	4	6	0
	Only occasionally	3	10	6	6	11	9	2
	Never	13	28	18	4	22	18	0
13	Often	2	12	2	3	15	6	0
	Sometimes	5	13	6	6	11	9	3
	Only occasionally	6	6	5	8	8	7	0
	Never	10	11	12	1	7	8	0
14	Often	1	5	0	4	2	4	0
	Sometimes	6	13	3	2	3	9	0
	Only occasionally	5	12	6	5	10	6	1
	Never	15	14	23	10	26	17	1
15	Yes	6	21	4	5	17	27	0
	No	21	22	28	17	25	11	3
16	None	13	11	17	11	8	5	1
	Office machines	4	10	5	1	17	8	0
	Outside noise	2	4	1	3	0	0	0
	Telephones	9	7	8	5	13	8	0
	Voices	7	28	9	7	26	19	1
	People walking around	2	2	3	7	9	5	0
	Mechanical noise	2	8	3	5	7	18	1
	Other	3	4	2	2	6	12	0

Appendix D (continued)

Question	Response	Floor 1	2	3	4	5	6	7
17	Prefer natural	4	6	4	9	7	7	0
	Prefer artificial	2	4	1	1	2	0	0
	Prefer combination	21	32	25	10	29	30	3
18	About right	26	37	22	3	25	18	3
	Too little light	3	4	8	19	14	14	0
	Too much light	0	0	1	0	3	4	0
19	Natural	23	36	19	1	27	27	3
	Unnatural	1	6	7	21	11	6	0
20	Natural	24	35	21	2	30	27	2
	Unnatural	1	7	4	20	6	7	0
21	Often	1	2	3	13	10	7	0
	Sometimes	4	9	7	7	7	14	1
	Only occasionally	4	6	5	0	6	9	1
	Never	18	26	17	3	20	11	1
22	Yes	7	12	8	7	35	2	3
	No	21	34	26	16	8	39	0
22	Often	0	1	0	1	3	1	0
	Sometimes	0	1	0	1	1	0	0
	Only occasionally	1	0	0	2	3	0	0
	Never	7	10	8	3	25	1	2
24	Very important	12	23	16	9	12	23	2
	Moderately important	7	17	11	8	20	15	1
	Not important	10	5	7	5	11	2	0
25	Yes	27	39	29	15	24	31	0
	No	2	8	5	8	19	10	3

Appendix D (continued)

Question	Response	Floor 1	2	3	4	5	6	7
26	About right	3	10	4	4	5	4	0
	Too big	0	0	0	0	0	0	0
	Too small	23	27	24	10	17	26	0
28	Yes	5	8	1	3	4	3	0
	No	22	30	25	12	20	25	0
30a	Often	0	0	0	1	0	0	0
	Sometimes	1	7	4	0	1	1	0
	Only occasionally	2	4	4	0	1	6	0
	Never	20	23	17	11	20	20	0
30b	Often	1	0	0	0	0	2	0
	Sometimes	0	1	0	0	0	0	0
	Only occasionally	2	2	0	0	0	0	0
	Never	21	31	24	12	22	26	0
30c	Often	1	1	0	0	0	1	0
	Sometimes	0	5	4	1	0	0	0
	Only occasionally	7	8	2	0	6	5	0
	Never	16	19	18	10	16	21	0
30d	Often	2	0	0	3	0	0	0
	Sometimes	1	0	1	0	0	5	0
	Only occasionally	3	3	2	2	4	4	0
	Never	18	30	17	7	18	15	0
30e	Often	5	9	13	5	0	3	0
	Sometimes	5	5	2	2	1	3	0
	Only occasionally	3	6	0	3	4	3	0
	Never	10	13	8	2	17	16	0

Appendix D (continued)

Question	Response	Floor 1	2	3	4	5	6	7
30f	Often	11	18	19	6	9	17	0
	Sometimes	2	5	2	0	3	1	0
	Only occasionally	1	0	1	2	1	2	0
	Never	9	8	3	1	11	7	0
30g	Often	7	15	17	4	7	13	0
	Sometimes	3	6	3	2	2	3	0
	Only occasionally	5	3	1	1	3	5	0
	Never	9	10	4	5	12	7	0
33	All the time	21	40	22	14	27	23	2
	Most of the time	7	5	11	7	14	13	1
	Very little	1	1	1	1	1	4	0
	Other	0	1	0	1	1	2	0
37	Male	13	33	15	17	22	23	2
	Female	16	14	19	6	21	18	1
38	17-25	3	4	11	1	7	3	1
	26-35	12	22	10	10	14	14	1
	36-50	9	8	4	8	10	13	0
	Over 50	5	13	9	4	12	8	1

Appendix E

Comparison of First and Second Questionnaire Results

Response to Lighting (in percent)

Question	Response	Questionnaire #1	Questionnaire #2	% Change
About how satisfied are you with the following aspect of your office? Lighting	Very satisfied	42	41	- 1
	Somewhat satisfied	20	32	+12
	Indifferent	6	1	- 5
	Somewhat dissatisfied	17	13	- 4
	Very dissatisfied	15	13	- 2
Do you prefer working by natural light, artificial light or a combination of natural and artificial?	Prefer natural	22	19	- 3
	Prefer artificial	4	5	+ 1
	Prefer combination	74	76	+ 2
In general, do you think the light level, artificial and natural combined, is about right for your work?	About right	68	66	- 2
	Too little light	28	30	+ 2
	Too much light	4	4	0
With the artificial light, does the color of objects in the room seem:	Natural	75	72	- 3
	Unnatural	25	28	+ 3
With the artificial light, does the complexion of office occupants seem:	Natural	75	76	+ 1
	Unnatural	25	24	- 1
Does the artificial light ever cause enough glare to bother you?	Often	15	17	+ 2
	Sometimes	22	23	+ 1
	Only occasionally	16	15	- 1
	Never	47	45	- 2
Do you have any other comments about the lighting?	No/no response	60	68	+ 8
	Dislike it	7	9	+ 2
	Like it	6	7	+ 1
	Too little	6	6	0
	Causes eyestrain	4	-	-
	Need more daylight	4	-	-
	Too much glare	-	5	-
	Too uneven	-	4	-

Appendix E (continued). Response to Noise

Question	Response	Questionnaire #1	#2	% Change
About how satisfied are you with the following aspect of your office? Noise level.	Very satisfied	23	19	- 4
	Somewhat dissatisifed	27	34	+ 7
	Indifferent	8	12	+ 4
	Somewhat dissatisfied	25	20	- 5
	Very dissatisfied	17	15	- 2
Does your office ever become so noisy that you find it difficult to work?	Yes	38	39	+ 1
	No	62	61	- 1
What noises do you notice most as you work?	None	8	30	+22
	Office machines	39	20	-19
	Outside noise	5	5	0
	Telephones	40	23	-17
	Voices	59	44	-15
	People walking around	17	13	- 4
	Mechanical noise	-	20	-
	Other	32	13	-19
	HVAC system	18	7	-11
	White noise	12	4	- 8

Response to Odor

Question	Response	Questionnaire #1	#2	% Change
About how satisfied are you with the following aspect of your office? Odor.	Very satisfied	38	31	- 7
	Somewhat satisfied	16	22	+ 6
	Indifferent	35	32	- 3
	Somewhat dissatisfied	6	9	+ 3
	Very dissatisfied	4	6	+ 2

Appendix E (continued). Response to Odor

Question	Response	Questionnaire #1	Questionnaire #2	% Change
Do you ever notice unpleasant odors in your office or work area?	Often	7	8	+ 1
	Sometimes	9	18	+ 9
	Only occasionally	20	22	+ 2
	Never	64	52	-12

Response to Ventilation

Question	Response	Questionnaire #1	Questionnaire #2	% Change
About how satisfied are you with the following aspect of your office? Ventilation.	Very satisfied	16	12	- 4
	Somewhat satisfied	25	22	- 3
	Indifferent	15	12	- 3
	Somewhat dissatisfied	24	27	+ 3
	Very dissatisfied	19	26	+ 7
Does it ever seem uncomfortably stuffy?	Often	22	32	+10
	Sometimes	29	29	0
	Only occasionally	20	25	+ 5
	Never	29	15	-14

Response to Temperature

Question	Response	Questionnaire #1	Questionnaire #2	% Change
About how satisfied are you with the following aspect of your office? Temperature.	Very satisfied	4	2	- 2
	Somewhat satisfied	15	12	- 3
	Indifferent	5	3	- 2
	Somewhat dissatisfied	28	32	+ 4
	Very dissatisfied	47	51	+ 4

Appendix E (continued). Response to Temperature

Question	Response	Questionnaire #1	Questionnaire #2	% Change
Does it ever get cold enough to make you feel uncomfortable?	Often	59	66	+ 7
	Sometimes	24	21	- 3
	Only occasionally	11	11	0
	Never	6	2	- 4
Does it ever get warm enough to make you feel uncomfortable?	Often	17	23	+ 6
	Sometimes	23	25	+ 2
	Only occasionally	24	27	+ 3
	Never	36	25	-11

Response to Windows

Question	Response	Questionnaire #1	Questionnaire #2	% Change
How important is it to you to have a window in your office or immediate work area?	Very important	40	45	+ 5
	Moderately important	42	37	- 5
	Not important	18	19	+ 1
Do you have a window or windows in your office or work area?	Yes	69	75	+ 6
	No	31	25	- 6
Are you able to see as much of the outside world as you would like from your desk?	Yes	18	15	- 3
	No	82	85	+ 3
Are you ever annoyed by the following aspect of the window or windows in your work area? Glare.	Often	3	1	- 2
	Sometimes	6	10	+ 4
	Only occasionally	7	12	+ 5
	Never	84	78	- 6
Are you ever annoyed by the following aspect of the window or windows in your work area? Overheating in summer.	Often	0	4	+ 4
	Sometimes	4	5	+ 1
	Only occasionally	2	13	+11
	Never	94	78	-16

Appendix E (continued). Response to Windows

Question	Response	Questionnaire #1	Questionnaire #2	% Change
Are you ever annoyed by the following aspect of the window or windows in your work area? Cold drafts in winter.	Often	30	25	- 5
	Sometimes	13	13	0
	Only occasionally	11	14	+ 3
	Never	46	48	+ 2
Are you ever annoyed by the following aspect of the windor or windows in your work area? Noise.	Often	0	2	+ 2
	Sometimes	1	1	0
	Only occasionally	10	3	- 7
	Never	89	94	+ 5
How about the size of your window, is it:	About right	13	19	+ 6
	Too big	0	0	0
	Too small	87	81	- 6
Do you have any other comments about the windows?	No/no response	61	71	+10
	Too small	12	10	- 2
	Too few	5	5	0
	Can't open them	10	4	- 6
	Dislike them	-	6	-
	Blinds malfunction	-	5	-
	Like them	-	3	-
	Like idea of windows	8	-	-
About how satisfied are you with the following aspect of your office? Window size.	Very satisfied	4	6	+ 2
	Somewhat satisfied	8	11	+ 3
	Indifferent	23	20	- 3
	Somewhat dissatisfied	20	24	+ 4
	Very dissatisfied	44	40	- 4

Appendix F

Occupant "Likes" and "Dislikes" on First Questionnaire
(N=265=100%)

Likes	Number of Responses
Location	55
Appearance	38
Newness	24
Cleanness	18
Atmosphere	17
Design	11
Lighting	10
Consolidation of agencies	10
Adequate space	9
Garage for parking	7
Comfortable environment	7
Clean restrooms	7
Being part of an experiment	6
Snack bar	6
Pleasant working environment	5
Use of solar energy	5
Parking	5
Nice furniture	4
Carpeting	4
Quietness	4
Office layout	4
Energy conserving features	3
Fellow workers	3
Maintenance	3
Temperature	3
Nice facilities	2
Display in lobby	2
Sound construction	2
Drinking fountains	1
Color of walls	1
Elevators	1
Water	1
Telephones after hours	1
Good security	1
Facilities for handicapped	1
Size	1
Everything	1

Dislikes	Number of Responses
Temperature	85
a. General complaints	11
b. Too cold	44
c. Poorly regulated	25
d. Too warm	5
Slow, unreliable elevators	70
Parking	48
a. General complaints	16
b. Lack of parking space	26
c. Paying for it	6
Windows	47
a. General complaints	1
b. Too few	20
c. Can't be opened	17
d. Too small	9
Ventilation	45
a. General complaints	30
b. Excessive drafts	10
c. Too erratic	5
Lack of a cafeteria	35
Heavy front doors	30
Lighting	29
a. Fourth floor	15
b. Other floors	14
Noise	17
Lack of space	9
Appearance	9
Poor location	8
Locked stairway on first floor	7
Lack of health facilities	7
Office layout	5
Computerized control of building	4
Restrooms	4
Working conditions	3
Lack of maintenance	3
Lack of public telephones	3
Parking garage	3
Atmosphere	3
Lack of control over venetian blinds	3
Lack of privacy	3
False fire alarms	2
Lack of an employee lounge	2
Security	2
Clocks	1

Appendix F. (continued)

Likes	Number of Responses	Dislikes	Number of Responses
		Carpeting	1
		Uncomfortable environment	1
		Loading dock	1
		Poor approach for handicappped	1
		Rough exterior walls	1
		Cold lobby	1
		Leaky basement	1
		Lack of emergency exits	1
		Lack of directory	1
		Employee facilities	1

Appendix G

Occupant "Likes" and "Dislikes" on Second Questionnaire
(N=213=100%)

Likes	Number of Responses	Dislikes	Number of Responses
Location	60	Temperature	105
Appearance	29	a. General complaints	12
Newness	16	b. Too cold	54
Lighting	15	c. Poorly regulated	27
Atmosphere	13	d. Too warm	12
Cleanness	12	Slow, unreliable elevators	39
Design	9	Parking	37
Adequate space	6	Ventilation	31
Parking	6	Windows	26
Fifth floor furniture	5	Lighting	23
Office layout	5	a. Fourth floor	11
Garage for parking	4	b. Other floors	12
Energy conserving features	4	Lack of a cafeteria	21
Quietness	3	Heavy front doors	16
Facilities	3	Noise	10
Snack bar	2	Design	8
Good security	2	Lack of humidity	8
Comfortable environment	2	Lack of space	7
Everything	2	Lack of health facilities	7
Consolidation of agencies	1	Building systems	5
Privacy	1	Appearance	4
GSA store	1	Lack of daylight	4
Carpeting	1	Lack of emergency exits	4
Maintenance	1	Blocked stairway	3
HVAC System	1	Office layout	3
Automatic doors	1	Lack of maintenance	3
		Location	2
		Atmosphere	2
		Lack of privacy	1
		GSA management	1
		Access for visitors	1
		Exterior lighting	1

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Jacqueline Elder, Robert L. Tibbott

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The General Services Administration built the Norris Cotton Federal Office Building in Manchester, New Hampshire, and chose it as a "demonstration project for studying the effectiveness of energy conservation techniques in the design and operation of a contemporary office building." User acceptance of both the innovative and conventional design features in the building was measured by administering a questionnaire to employees shortly after occupancy of the building and again eight months later. The most positively rated feature overall was the lighting, but reaction to the high pressure sodium lighting system as installed in the Norris Cotton Building was strongly negative. Response to noise levels and disturbances was about evenly divided, but workers in open-plan offices were less satisfied with the noise climate than workers in partitioned offices. Most respondents were dissatisfied with the temperature and ventilation conditions and the small windows in the building. In general, the occupants rated the building much higher in appearance than their previous offices, slightly higher in terms of suitability for performance of their jobs, and slightly lower with respect to comfort. A literature review of recent survey studies of the office environment is included.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Energy conservation; lighting; man/environment research; noise; office building; post-occupancy evaluation; questionnaire; temperature; ventilation; windows

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